MILITARY HYGIENE

R. CALDWELL

SECOND EDITION


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BY

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SECOND EDITION

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PREFACE TO THE SECOND EDITION

THE kindly reception accorded to the appearance of this book, in my own country and in the United States, has encouraged a hope that a second venture, on a somewhat more ambitious scale, might not be out of place.

I must explain that although the present edition is primarily addressed to officers of the Royal Army Medical Corps, it is my earnest hope that it may prove useful to all branches of the service, and I have therefore followed my original plan of endeavouring to convey information in the simplest language consistent with the subject.

As in the first edition, I have largely used my own experience as the basis of information, although I am fully aware of the appearance of egotism entailed, and on account of which I must ask the kind indulgence of readers. Apart from the above source, I have drawn freely from the Army Medical Reports, the Reports of the Surgeon-General United States Army, the Statistique Médicale de l'Armée, and from articles in the *Journal of the R.A.M.C.*, the *Military Surgeon*, and the publications of learned societies, British and foreign. I have also made use of the following standard works of reference—viz., Thresh's 'Examination of Waters and Water-Supplies,' Hewlett's 'Bacteriology,' Huggard's 'Climatic Treatment of Disease,' Bird's 'Geology,'

Luff and Page's 'Chemistry,' and Scott's 'Meteorology,' to the authors of all of which I am distinctly indebted.

Five new chapters have been written, several of the old chapters have been recast, and numerous additions and alterations have been made throughout the remainder. The geological map, which has been specially prepared by Messrs. Longmans, Green and Co., may be of service in the selection of camping-grounds.

In the matter of illustrations, I have received valuable help from Major R. J. Blackham, R.A.M.C.; Captain H. d'A. Smith and Captain R. B. Unwin, the Suffolk Regiment; Major F. P. Reynolds, United States Army; Oberstlieutenant Conrad Escher, Stabschef des Territorial Kreises VI., and Oberst Steinbuch, Kommandant der Inf. Brigade XI.; Quartermaster-Sergeant Revill, R.E.; and Dr. Gubb of Algiers.

I have also to express my thanks to Colonel H. G. Hathaway, A.M.S., for an account of his scheme for the transport of sick and wounded of cavalry, and to Dr. Lachaud, Member of the Chamber of Deputies and of the Army Commission, for permission to reproduce a design for French infantry barracks from his well-known work, 'Notre Soldat.'

As on a former occasion, I have to thank my publishers, Messrs. Baillière, Tindall and Cox, for the care expended on the work of production.

R. C.

ROBERTS' HEIGHTS,
PRETORIA.
July, 1910.

PREFACE TO THE FIRST EDITION

In the following pages I have endeavoured to give a short account of those principles of sanitation which most nearly affect the soldier in his every-day life, whether at home, abroad, or in the field. The different points have, as far as possible, been illustrated by references to the histories of celebrated campaigns, to official records, and to my own experience. I must apologize for an appearance of egotism which the last-named course may have involved, on the ground that I was anxious to make personal knowledge, as far as it went, a ground for conclusions arrived at.

I should explain that I was tempted to undertake this task in the hope that the present rapidly growing interest in military sanitation might render such an attempt acceptable to officers of the army in general, as well as to officers of the medical services. With the above object in view, I have entered on explanations and used modes of expression which would be altogether out of place in a work intended solely for members of the medical profession. I must, on the other hand, admit that the complete avoidance of technicalities was impossible if the book is to be found worthy of perusal by those to whom it is mainly addressed.

I think it well to state that the chapter on 'Routine Duties' was written in the hope that it would be of use to junior medical officers of both the regular army and the auxiliary forces.

As the volume was in the press before the publication of Part III. of the Report of the Commission engaged in the investigation of Mediterranean fever, I much regret that I have been unable to include any account of the most recent work carried out regarding this disease.

My principal sources of recorded information have been the Army Medical Department Reports, the Report by Surgeon - General Sir William Wilson on the medical arrangements in the South African War, and recent reports of the Surgeon-General at Washington to the Secretary of War. For copies of the last-named documents I am indebted to the kindness of Major M. W. Ireland, United States Army.

I have also made considerable use of the numerous valuable contributions found in the *Journal of the Royal Army Medical Corps* and in the *Journal of the Military Surgeons, U.S.A.* I should here state that extracts have, as a rule, been given verbatim and *in extenso;* there should, therefore, be little or no risk of the conveyance of meanings other than those originally intended.

My hearty thanks are due to Lieutenant-Colonel H. G. Hathaway, R.A.M.C., for a description of his design for the support of sick and wounded in the saddle, together with his scheme for ambulance work with mounted troops on service. Like thanks are due from me to Major E. M. Pilcher, D.S.O., R.A.M.C., for a most valuable account of a personal experience of epidemic cholera, and to Captain J. Crawford Kennedy, R.A.M.C., for practical information in connection with Malta fever.

In the matter of illustrations, I have received valuable help from Major A. C. Williams, Chief Supply and Transport Officer, Meerut; Captain A. N. E. Browne, the Highland Light Infantry; Captain F. Reynolds, United States Army; and Sergeant-Major A. Harwood, R.A.M.C. I must also express my obligation to Professor J. Glaister, Glasgow University, for his kindness in allowing me the use of blocks of figures in his well-known 'Manual of Hygiene.'

In conclusion, I have to thank my publishers, Messrs. Baillière, Tindall and Cox, for their generosity as regards illustrations and for the care they have expended on the production of the work.

R. C.

HILLSBOROUGH BARRACKS, SHEFFIELD,
September 6, 1905.

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CHAPTER I

THE WORK OF THE MICROBE

'NATURE's discipline is not even a word and a blow, and the blow first; but the blow without the word.'* In other words, disaster rapidly follows conduct not regulated in accordance with the laws of Nature, and although certain dangers to health make themselves evident by direct appeal to the senses, the general truth contained in this statement of a philosopher and scientist cannot be more applicable than in the case of matters relating to the subject of preventive medicine.

There is little doubt concerning the fact that many unseen perils result directly from our modes of life, and it follows that with increasing knowledge we should be able to control the occurrence and spread of a variety of morbid conditions, the origin of which was in former times either imperfectly understood or attributed to supernatural causes. It is now an established fact that the existence of disease can largely be traced to certain minute forms of vegetable life which, for the sake of convenience, may be grouped under the generic term of microbes, micro-organisms, or of bacteria. These forms are conveniently classified in two main divisions—viz., the bacillary and the coccoid. As a general statement, the former can be said to occur as rods, and the latter as spherical bodies.

Although we are perfectly justified, as the result of existing

* 'Lay Sermons, Addresses, and Reviews,' by T. H. Huxley, LL.D., F.R.S.

evidence, in fully accepting the fact that certain definite bacterial forms are respectively the causative agents of certain definite forms of disease, it would nevertheless be unjustifiable to assume that these forms are in the possession of unalterable characteristics, or that they may not have been derived from ancestors entirely different to themselves, both in regard to appearances and potentialities.

It is well known that species, even in the highest forms of life, is by no means immutable, and without attempting to enter on the vexed question as to whether man is, or is not, the descendant of monkeys, the changes which surrounding conditions effect on all living beings are, as a general statement of fact, admitted without dispute.* Such being the case, there should be no difficulty in accepting the likelihood of rapid changes in living forms so lowly organized as to be insusceptible of the classification applied to beings in the higher states of existence, and which multiply at so marvellous a rate that 'the number of individuals which might arise from a single bacterium in three or four days is almost inconceivable, and would, *en masse*, weigh thousands of tons' (Hewlett). This increase is, however, rendered impossible by natural causes. The study of bacteria should, in itself, be sufficient to carry conviction concerning the constant occurrence, among these forms, of changes of a sufficiently profound nature resulting from modifications in surrounding conditions. In the case, for instance, of the anthrax bacillus the mode of reproduction is well known to be dependent on the supply of oxygen, while the virulence of the germ can be raised or diminished according as growth is carried out in the body of a susceptible or, on the other hand, of an insusceptible animal. Virulence can also be lowered by the addition of certain chemicals to the culture media. Many other instances of a like nature could be given, and full information on this subject is to be found in standard works of reference. Perhaps the most striking, and at the same time familiar, example of the kind

* 'Changed conditions of life are of the highest importance in causing variability' (Darwin, 'Origin of Species,' chap. i.).

is that presented by vaccination. In this case, the disease of smallpox, by its passage through the cow, becomes so modified that, as stated by McVail, the changes which take place in the body of the animal have the result of 'removing the objectionable and retaining only the valuable part of the disease.'

It is not to be imagined that bacterial forms are mainly harmful; on the contrary, many of them, as will appear later, are essential to the continuance of life as we know it. Other forms, consisting of those found in the alimentary canal of man and the lower animals, are, as far as we know at present, not only perfectly harmless, but possibly fulfil useful purposes in the general scheme of Nature, although, in the latter connection, it must be admitted that present evidence points in the opposite direction. Having regard, however, to preceding statements relative to certain changes in the virulence of disease-producing forms, it is reasonable to assume the possibility of a converse side to observed facts. In other words, is it, or is it not, possible for innocent forms to assume virulent powers under the influence of external conditions?*

Experience, as distinct from results obtained in a laboratory, answers this question in the affirmative. Experiments, no matter how ably conducted, can never have the same weight as conclusions which have been arrived at by observation of the unaltered operations of Nature, and the latter may fairly claim priority of consideration over evidence of a purely negative character, obtained from a study of

* 'Quite recently it has been found that there are non-pathogenic microbes of wide distribution which, in every point except virulence, closely resemble the specific microbes of enteric fever and diphtheria, and non-pathogenic bacilli have been found to be protective against anthrax. Some authorities regard these harmless microbes as being probably generically identical with the virulent microbes that they resemble, and therefore capable of assuming a virulent character if cultivated under suitable conditions, a view that reintroduces the *de novo* hypothesis in a new form' (Whitelegge, 'Hygiene and Public Health'). The significance of these facts as regards the present question is sufficiently clear.

artificial conditions. Facts in support of the theory of the conversion of innocent into dangerous forms of microbial life are readily forthcoming, and can be furnished copiously from the history of military campaigns.

There is, above all, one salient feature in connection with the medical histories of war—namely, the wholesale occurrence of epidemic disorders. It is also most noteworthy that these epidemics appear to be largely, if not altogether, dependent in their origin on the physical environment of the troops, and constantly take the general form of gastro-intestinal disturbance. In Hume's 'History of England' we read that during Cromwell's campaign in Ireland, in the month of October, 1649, shortly after the sack of Drogheda and the surrender of Wexford, 'the English had no further difficulties to encounter than what arose from fatigue and the advanced season. Fluxes and contagious distempers crept in amongst the soldiers, who perished in great numbers.' In a letter to the Speaker of the House of Commons, dated November 14, 1649, Cromwell writes as follows: 'I should not doubt but by the addition of assessments to have your charge in some reasonable measure borne, and the soldier upheld without too much neglect or discouragement, which sickness, in this country so ill agreeing with their bodies, puts upon them; and which this winter's action, I believe not hitherto known by the English in this country, subjects them to. To the praise of God I speak it, I scarce know one officer of forty amongst us that hath not been sick. And how many considerable ones we have lost is no little thought of heart amongst us. Wherefore I humbly beg that the moneys desired may be seasonably sent over; and those other necessaries—clothes, shoes, and stockings—formerly desired; that so poor creatures may be encouraged. . . . And certainly the extending your help in this way at this time is the most profitable way speedily to effect it. And if I did not think it your best thrift, I would not trouble you at all with it.'* Cromwell's anxiety as to the physical welfare of his men, as shown in the above letter,

* 'Oliver Cromwell's Letters and Speeches,' by Thomas Carlyle.

is evidence that he attributed the presence of sickness to the hardships which the army was undergoing. Again, in September of the following year, Cromwell's army suffered severely from dysentery, when hemmed in by the Scotch on the sands of Dunbar. The position of the force was at this time almost hopeless. The passes between Dunbar and Berwick, the only roads by which supplies could travel, were occupied by the enemy; in front of the English was an impregnable position held by a cautious and capable leader, and the nature of the shore rendered retreat by sea a matter of doubt, or even of impossibility. While Cromwell's soldiers, in the absence of food and other supplies, wasted rapidly from disease, the Scotch campaigning in a friendly country, were furnished with many necessaries, and it is now a matter of history that an ill-considered advance robbed Leslie of victory by giving Cromwell that opportunity which his own genius and the fighting powers of his men converted into a hopeless defeat of the army to which the exhausted condition of its opponents should have assured complete success. Writing to Sir Arthur Haselrig on the condition of his army previous to the battle, Cromwell says: 'We are upon engagements very difficult. The enemy hath blocked up our way at the pass at Copperspath, through which we cannot get without almost a miracle. He lieth so upon the hills that we know not how to come that way without great difficulty, and our lying here daily consumeth our men, who fall sick beyond imagination.' Again, in a letter to Lieutenant-General Ireton written at the same time, the following passage occurs: 'We made often appeals to God; they appealed also. We were near engagements three or four times, but they lay upon advantages. A heavy flux fell upon our army, brought it very low from fourteen to eleven thousand.'*

After the Battle of Leuthen the sufferings of the defeated Austrians were exceptionally severe. Carlyle thus describes the condition of part of the army during its retirement through Silesia: 'Wild weather for Ziethen, still more for

* 'Oliver Cromwell's Letters and Speeches,' by Thomas Carlyle.

Karl among the Silesian Bohemian hill-roads; heavy rains, deep muds, then sudden glass with cutting snow blasts. "An army not a little dilapidated," writes Prince Karl, almost with tears in his eyes. "Army without linens, without clothes, in condition truly sad and pitiable, and has always, so close are the enemy, to encamp, though without tents." Did not get to Königsgrätz and safe shelter for ten days more. "Counted at Königsgrätz 37,000 rank and file, 22,000 of whom gone to hospital by the doctor's report."'*

If the 22,000 men 'gone to hospital by the doctor's report' were an expression of the normal health of the district, it is rather hard to account for the existence of a population.'

After, and before the passage of the Delaware, the condition of Washington's army was to the last degree pitiable, and is vividly described in Sir George Trevelyan's 'History of the American Revolution':

'Inclement weather and incessant toil and exposure were all the more afflicting to soldiers who were worse than badly fed by their employers, and who had not the leisure or the permission to cater for themselves. The administrative departments had completely broken down, and, indeed, since their wholesale and repeated losses by capture of waggons and draught horses, the transport officers had not much left to administer. Carrying next to nothing along with them, the Provincials could procure very little from the country through which they travelled. Their force was small, and they had no men to spare from the duties of watching the enemy and guarding the camp. The militia were so prone to desert that they could not safely be trusted at a distance from headquarters; and as long as Cornwallis managed the pursuit, the British skirmishers had been active, audacious, and importunate. For all these reasons the American commander did not venture to send out foragers in any great number over a considerable extent of country.

'At that season of the year the harvest of maize had long ago been cut and gathered, and Washington's soldiers could

* 'History of Frederick the Great,' by Thomas Carlyle.

not, like the troops of General Jackson in the War of the Secession, "cut their rations off the stalk" in the cornfields along their line of march. There is a casual mention of half a pint of whisky having been served out daily to every American, but whether or not they received the allowance regularly, and whatever it may have done towards keeping them contented, they certainly got very little solid or wholesome food to sustain them. They starved all the way from Hackensac to Newark, and from Newark to Brunswick, and by the time they came in sight of the Delaware, those mothers and sisters who had spun and dyed their garments would with difficulty have recognized their pinched faces and discoloured rags.

'The fate of the sick and the wounded was heartrending. So far back as October there were five battalions brigaded together above Haarlem, which had only one surgeon's mate among them. The stores of drugs and bandages had run out early in the retreat; nor could the deficiencies of the medical chests be supplemented from the local resources of those petty towns which the army traversed. Many of the soldiers who were too ill to walk were left behind in the utter dearth of carriage, and most of them died for want of care. A very large proportion of the troops who retired across the Delaware were attacked by pneumonia, dysentery, and camp fever, and few who once were prostrated ever recovered and survived. During the coming quarter of a year 3,000 deaths occurred in and about Philadelphia, where seventy funerals sometimes took place on the same day. Many of those militiamen who left the ranks at one point or another of the retreat carried away the seeds of disease in their frames. They died at their homes in great numbers, and spread typhus far and wide about the neighbourhood where they resided.'*

There is not the faintest evidence that the sickness amongst the Americans had any other origin than the hardships which were endured. The history of the districts which

* 'History of the American Revolution,' by the Right Hon. George Otto Trevelyan, Bart.

were the scene of hostilities utterly disproves any theory of endemic causation.

A very striking instance of the results of external conditions on troops is found in the history of the Valmy campaign in the Argonne district of France in September, 1792. On this occasion a fully-disciplined and organized Prussian force was hopelessly repulsed by newly-raised French levies consisting of individuals whose principal qualifications for military service consisted in the possession of a purely emotional form of courage, and who, in the words of an almost contemporary writer, 'ne semblaient connaître d'union que lorsqu'il s'agissait de commettre des atrocités.'*

The numerical and military superiority of the Prussians was of no avail against an acute epidemic of dysentery, caused by exposure and improper food; and reference to the history of the times leaves no doubt as to the appalling sufferings which these troops were forced to undergo. Plentiful supplies had maintained the efficiency of the Republicans, a circumstance which, in spite of military incapacity, gave them a victory which under other conditions they would scarcely have earned. It is a remarkable fact, as bearing on the origin of disease in external conditions in the way of hardship, that although the opposing armies were in the immediate proximity of each other, in the one case the general health remained fairly satisfactory, while in the other, dysentery raged to such an extent that, in the words of the writer already quoted, 'les fosses d'aisance étaient pleins de sang, de malheureux soldats y étaient tombés, et y avaient péri.'

It is evident that the sickness was not due to endemic causes, but was the direct result of circumstances acting on one of the belligerent forces only.

In Napier's 'History of the Peninsular War' it is stated that in September, 1809, 'the pestilent fever of the Guadiana assailing bodies which fatigue and bad nourishment had already predisposed to disease, made frightful ravages; dysentery, that scourge of armies, raged, and in a short

* 'Vie et Mémoires du Général Dumouriez' (Paris: Beaudoin Frères).

time several thousand men died in the hospitals.' Some idea of the sickness amongst our troops in the Peninsula may be gathered from the following figures taken from the work just referred to :

SIR ARTHUR WELLESLEY'S ARMY.

Total Under Arms.	In Hospital.
18,419, April 22, 1809	2,038
20,653, May 1	2,357
22,353, June 25	3,246
28,987, July 25	4,827
23,665, September 25	8,827

Sir Arthur Wellesley landed on April 22, 1809, and the steady increase in the roll of sickness, with the progress of the campaign, is most striking, particularly when read in connection with the preceding extract.

The following returns, taken from the Imperial Muster Rolls, furnish useful information as to the health of the French army. It is a matter of regret, at the same time, that these figures do not comprise periods corresponding to those already cited in connection with our own troops.

CACERES, MASSÉNA COMMANDING.

Total Active Army.	In Hospital.
115,529, April 10, 1810	16,056
71,573, May 15	12,014
67,746, August 15	14,112
98,614, September 27	18,142*

It is plain that these numbers give no information concerning the proportion of wounded to sick, but there is every reason to believe that the wounded contributed towards the total to a comparatively insignificant extent. During the first of the above periods—namely, from April 22, 1809, to September 27, 1809—by far the heaviest loss incurred was at Talavera, where the total number of wounded of all ranks amounted to 3,917, and no other engagements took place at

* Napier.

this period of the war which in any way approached the above as regards casualties.

Referring to the general condition of the army in 1809, Napier states that Sir Arthur Wellesley, 'although burning to enter Spain, was kept back by a variety of difficulties. He had been reinforced with 5,000 men after his return from the Douro, and in the preceding operations the killed and hurt in battle had not exceeded 300 men; but the deaths from sickness were numerous, 4,000 in hospital, and 1,500 employed in escort and depot duties. As an army, therefore, it was weak in everything but spirit; the commissariat was without sufficient means of transport, the soldiers nearly barefoot and totally without pay, the military chest empty, the hospitals full.'

Concerning Masséna's army, the period which has been cited covers no sanguinary engagements, and the men in hospital were almost entirely composed of sick. It is noteworthy that both sides encountered great difficulties in obtaining adequate supplies; records of the exact nature of the rations would now be invaluable.

Interesting evidence of the effect produced by scanty and improper food on men exposed to a rigorous climate is found in the letter of a French Staff Officer, Colonel Desprez, to King Joseph, the brother of Napoleon.

This letter bears reference to the retreat of the French army from Moscow:

'Il est impossible de peindre jusqu'à quel point la disette s'est fait sentir pendant plus d'un mois, il n'y eut point de distributions, les chevaux morts étaient la seule ressource, et bien souvent les Maréchaux même manquaient de pain. La rigueur du climat rendait la disette plus meurtrière, chaque nuit nous laissions au bivouac plusieurs centaines de morts. Je crois pouvoir, sans exagérer, porter à cent mille le nombre qu'on a perdu ainsi et peindre avec assez de vérité la situation des choses en disant que l'armée est morte.' *

No evidence could be more conclusive than the history of

* Napier's 'History of the Peninsular War,' vol. v., Appendix V.

the Crimea as to the disease-producing factors of an army in the field. In this particular connection certain letters of the late Sir Thomas Longmore, written from the seat of war, throw lurid light on the actions of responsible authorities.*

It would be an easy matter to further multiply instances of the above nature, down to the recent war in South Africa, but to do so would serve no useful purpose. Enough has been said to illustrate the constant advent of epidemic sickness amongst troops on service. It should be perfectly clear that had these occurrences been the result of endemic conditions, the regions in question could not have been populated by any race of human beings physiologically resembling those now in existence, and we are therefore forced to the conclusion that the epidemics were the direct outcome of conditions peculiar to active service in the field. It is inconceivable that Flexner's or other bacillus pre-existing in the soil or water of the Argonne woods, attacked the Prussian invader, and replaced by its results what was lacking in military endowments amongst the soldiers of the Republican army. It is equally unreasonable to assume that the sands of Dunbar normally contained the organism which came within a measurable distance of leading to the complete overthrow of Cromwell's troops. The same reasoning applies to other instances, of a similar nature, which have been cited.

The ultimate explanation of these facts is, of course, far from certain, but a reasonable supposition may at the same time be entertained concerning their causation. When we reflect that the alimentary canal swarms with countless myriads of micro-organisms, under constantly varying conditions of food, pressure, movement, and at times of temperature; and when, in addition, the ready variability of these lowly forms of life is taken fully into consideration, it need no longer be a matter of surprise that those chemical changes which are doubtless caused by irritating ingesta, coupled with the congestion due to reflux of blood from the surface under the influence of exposure to cold

* *Journal R.A.M.C.*, March, 1904.

should so far alter the environment of the forms in question as to produce capacities in the latter, which, under ordinary circumstances, could never have been assumed.

If the above explanation in any way approaches the truth, it must tend directly to the belief that the health of an army in the field is likely to depend on internal as much as on external causes, and that the search in soil or water for endemic sources of disease may, at times, divert attention from the appalling potentialities which already exist in our own bodies.

It is not, indeed, going beyond actual knowledge if we consider the alimentary canal as a bacteriological laboratory of an infinitely complicated nature, in which virulent forms can readily be called into being under appropriate conditions; and such a fact, from a purely practical point of view, is not unworthy of the careful attention of army medical officers.

Besides the alimentary canal, there is another source from which disease-producing bacteria are likely to be brought into existence. The soil when soaked, as it often is in camp, with organic refuse of all sorts, can reasonably be expected to contain an enormous variety of germs, and when we remember how the above can be made to vary, under the artificial conditions of the laboratory, as regards shape, virulence, mode of propagation, etc., there should be no difficulty in grasping the extreme likelihood of similar changes taking place in the superficial layers of filth-saturated ground.

How far, in the instances cited, the outbreaks of sickness were due to changes arising within the bodies of the men; and how far to virulent forms manufactured in the soil or elsewhere, as a consequence of the insanitary condition of camps and bivouacs, is a question which cannot be answered. Without, however, attempting to assign to each of these causes its due share in the production of disease, we may admit that history furnishes sufficient evidence to support the theory of a capacity on the part of innocent germs to assume, under favourable conditions, powers of a deadly character. It is fair to add that the provisional

acceptance of such a possibility is entirely in accordance with established scientific facts, and is most strongly supported by recent practical experience, notably in connection with occurrences in South Africa. It is, in fact, justifiable, as a guide to action, to firmly hold the belief that we are surrounded by, and carry in our persons, germs which under normal conditions are innocent, and, in some cases, useful, but which are capable of becoming, as a result of human action, enemies of the deadliest description, just as higher forms of life, such as the horse or dog, may, under injudicious treatment, develop characteristics of a vicious or otherwise undesirable nature, and thus prove a source of danger or discomfort to those who should have held them in effectual control. Such an illustration may appear to be trivial, but it embodies a principle upon which the well-being of the human race depends, and which has no wider applicability than in the field of military medicine.

CHAPTER II

IMMUNITY

For present purposes immunity, perhaps, may best be defined as the power of the animal organism to resist the invasion of infective disease, or, in other words, of disease originating from micro-organisms which multiply at the expense of the body to which they have gained access. It may at first sight seem strange that the principles of such a highly technical subject should be considered to form part of the study of military hygiene; but any feeling of surprise should disappear if we remember that it is owing to the brilliant work carried out in this particular direction by Wright, Douglas, Leishman, and others, that one of the most fertile causes of death and invaliding among troops, in the shape of enteric fever, has been so remarkably modified in late years. It is not, however, necessary to limit our mental view to the splendid results achieved regarding a single disease, as we have every reasonable ground for hoping that, by means of a further application of ascertained facts, other widely-spread causes of military inefficiency will be materially diminished, or even altogether eliminated.

Any attempt to give a detailed account of the phenomena of immunity would at present be quite out of place, but a general outline of certain broad principles may at the same time be useful, for there is no doubt that to understand a remedial measure is often to appreciate it. Men have a natural fear of what they do not understand, particularly if they think that it partakes of the nature of an experiment

on themselves, and so often fail to take advantage of the protection which the State places within their reach.

One of the most remarkable functions of the animal frame, and one without which the continuance of life would be impossible, is that of producing substances known as 'antibodies,' which destroy or otherwise alter invading substances known as 'antigens.' Hewlett states that all substances which produce 'antibodies' are 'antigens,' and the definition is an excellent one.

An example may help to make the matter clear:

Stripped of all unnecessary details, and for explanatory purposes only, the blood may be described as consisting of minute bodies known as corpuscles and of a fluid known as the serum, in which the corpuscles are suspended. It must further be stated that the corpuscles are of two kinds —viz., the red and the white. The function of the former is to carry the oxygen from the lungs to the body generally, and the function of the latter is, among other things, to defend the body against the attacks of dangerous organisms in the shape of disease-producing microbes. The red corpuscles are biconcave, motionless discs, and have a diameter of about $\frac{1}{3200}$ inch; viewed *en masse*, they give the red colour to the blood. The general shape of the white corpuscles is round, but it is constantly changing, as the corpuscles extrude processes which serve for the purpose of locomotion and for seizing chance prey in a manner to be presently explained. The white corpuscles are somewhat larger than the red, but are far less numerous.

Under ordinary circumstances the blood of a guinea-pig has no effect on the blood of a rabbit; but if a guinea-pig is injected with an antigen in the form of rabbit's blood, antibodies are formed, and the blood of the guinea-pig acquires the power of dissolving the red corpuscles of the rabbit.

It is also a well-known fact that in the case of men and animals suffering from certain diseases the blood acquires the power of aggregating into clumps the organism which causes the particular disease which may be present. This phenomenon is known as 'agglutination,' and will be referred

to again. It is an ordinary means of ascertaining the nature of sickness in doubtful cases.

It now remains to be seen how facts of this kind apply to the problem of human immunity. In general terms, the infective diseases with which we have to deal may be classified under two headings—viz., (1) those resulting from poisons, produced by microbes, the microbes themselves being commonly absent, and only the poison finding its way into the general system; and (2) those produced in a like manner to the above, but the microbes themselves being present, and acting, in fact, as the carriers of the poison. These two forms of poisons are known respectively as 'extra-cellular' and 'intracellular.' An example of the former is found in diphtheria. It is quite true that in prolonged cases the microbes have been found in the spleen, lungs, kidneys, and even in the blood; but as a rule they tend to remain in and about the original point of attack—viz., the tonsils—where they form poisons, which spread through the system and produce the constitutional symptoms of the disease.

Another, and possibly a better, example is found in tetanus, commonly known as 'lockjaw.' In this disease the causative organisms remain at or near the site of entry, the latter being almost invariably a wound, and the general symptoms are entirely due to the presence of the poison which has been absorbed.

The treatment of these diseases depends upon the artificial production of antibodies, it being clearly understood that each disease has its own antibody, and that the antibody of one disease has no antidotal effect against the poison of the other; in technical language, the antibodies are 'specific' in their action.

It must be admitted that in the case of tetanus our efforts have not been attended with much success, the comparative failure being caused by the fact that the poison combines so rapidly with the nervous tissues that, having regard to the slow development of the symptoms, it is impossible to effect the desired separation. This circumstance is the more regrettable as it is well known that the disease is particularly

liable to attack wounded soldiers left unsuccoured on the field of battle, and who may be too severely injured to protect themselves against the entry of germs by the means provided in the shape of the first field dressing.

In the case of diphtheria, however, the results attained have been of a most brilliant description, and the procedure employed is somewhat as follows: Virulent diphtheria germs are grown in broth until a considerable quantity of poison has been formed, and the broth is then filtered so as to get rid of the germs. We are now dealing with a highly poisonous germ-free filtrate, and this filtrate, beginning with very small doses, is injected gradually into selected horses, until the animals, by virtue of the antibodies which have been produced, are able to receive with impunity a relatively enormous quantity of the poison. The horses are next bled, and the liquid portion of the blood—*i.e.*, the serum—is bottled with every possible precaution against contamination. This bottled serum is technically known as diphtheria 'antitoxin'; it is the antibody produced in the horse in excess of that which has neutralized the 'antigen' in the form of diphtheria poison.

The injection of antitoxin as a curative agent is now a commonplace of medical practice, and to a lesser extent it is used as a preventative; in both cases it acts by supplementing the natural antibodies of the human organism, or possibly by furnishing antibodies where such are absent. In the *Journal of the R.A.M.C.* for September, 1909, there is an interesting account of an outbreak of diphtheria in the Duke of York's Royal Medical School, in October, 1908. Lieutenant-Colonel Sir Joseph Fayrer, R.A.M.C., who describes the outbreak, administered injections as a preventative to 535 boys, 38 students, and 1 officer, and what might have proved a most serious epidemic was stamped out (*Journal of the R.A.M.C.*, September 19, 1909). Other means of prevention were naturally not neglected, and it is impossible to say which factor contributed most to the successful issue; the instance is, however, well worth mentioning as proof of the value which is held by observers of great experience to attach to this mode of dealing with epidemic disease.

We must now pass to the second form of infective disease —viz., that form which is produced by the microbes themselves carrying the poison into the body. If the microbes spread widely through the system, the condition is known as one of general infection, or if they tend to remain in one locality, then it is known as a local infection.

It has been found that if an animal is injected with gradually increasing doses of certain poisonous microbes, a stage is reached when the animal can receive a dosage which would most certainly have killed it under ordinary circumstances. The serum of the animal is now found to have a destructive action on the kind of microbes which have been injected. Furthermore, the antibody which exercises this destructive action is found to consist of two parts—viz., the 'complement' and the 'amboceptor.' The former is an unstable body, believed to be normally present in the blood; while the amboceptor, which is comparatively stable, is only formed as the result of the inoculation. It has also been ascertained that each body is powerless by itself, and that the amboceptor acts as a link between the complement and the microbe.*

* The serum diagnosis of syphilis is based on these facts. The principle underlying the method is found in the circumstance that the complement will only unite with the amboceptor of which the corresponding antigen is present. The original procedure, in general terms, was as follows: the antigen, in the form of an extract of the spleen or liver of an hereditary syphilitic fœtus, was mixed with the suspected serum, the latter being heated to 56° C. for half an hour to destroy the complement, while the deficiency in the latter direction was made good by the addition of the serum of a normal guinea-pig. If the suspected serum contained an amboceptor caused by syphilitic infection, union between this amboceptor and the complement in the guinea-pig's serum would take place for purposes hostile to the antigen; but if no such amboceptor were present, the complement would remain free to attach itself elsewhere. Whether the complement remained free or otherwise was determined by mixing sheep's red-blood cells, washed in normal saline solution, with the serum of a rabbit previously injected with cells of the above kind, and so containing an amboceptor destructive of the same. As in the former case the serum was heated to destroy the complement, and hæmolysis, or, in other words, destruction of the red cells, of the sheep, depended on whether the complement could be replaced.

When the above facts came to light, it was hoped that practical results would ensue, it being assumed that the serum of an animal treated as above would certainly have a curative, or protective action, possibly both. But these hopes were doomed to disappointment, or, at least, they were only realized to a partial extent. The complement, as just stated, is an unstable body, and in drawn blood it disappears in a comparatively short time ; while the amboceptor, as also previously explained, is ineffectual when alone. By injections of fresh serum, efforts have been made to make good the deficiency, but the outcome has certainly not been satisfactory.

It has been reserved for Wright and Douglas, the brilliancy of whose work can scarcely be overestimated, to point out the correct lines on which diseases of the nature now in question can be dealt with. Instead of using the serum of an immunized animal, these workers used the dead bodies of the microbes themselves. By this means they elaborated what is known as the opsonic theory, or what, in the minds of many persons well qualified to judge, is the opsonic fact. Allusion has already been made to the defensive powers of the white blood-corpuscles, and it may now be stated that these bodies have been proved, by microscopic research, to be capable of capturing and destroying invading microbes ; the microbe being first seized by an extruding process and

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The rabbit's serum and the sheep's cells were added to the mixture of antigen, suspected serum, and complement ; and if the last named was free, it united with the rabbit's serum, and hæmolysis of the sheep's cells took place, but if in combination, the cells remained unaltered. The procedure has been considerably simplified by the discovery of Landsteiner, Porges, and Maier, that a suitable antigen could be extracted from non-syphilitic organs ; while another advance was made by Bauer, who showed that human serum—syphilitic or otherwise—would bring about hæmolysis of sheep's red cells, and that consequently the rabbit's serum was unnecessary.

Lastly, Hecht has used a non-heated serum with success, and has so dispensed with the artificial addition of a complement in the shape of guinea-pig's serum.

For further information see article by Captain T. H. Gibbon, R.A.M.C. *Journal of the R.A.M.C.*, February, 1910.

then conveyed within the body of the corpuscle, where it shortly perishes. The process, technically known as 'phagocytosis,' is almost suggestive of purposeful and, therefore, intelligent, action.

Wright and Douglas found that the corpuscles, when acting alone—*i.e.*, without the serum, the latter being replaced by normal saline solution—were to all intents and purposes powerless, but that their function was restored on the addition of normal serum; while heating the serum to 60° to 65° C. again arrested the process of microbial destruction. Following this line of inquiry, it was ascertained that, by the injection into the animal organism of a relatively small number of microbes which have been killed by heat—care being taken to keep the temperature below the degree which would prove detrimental to the contained poisons—the destructive power of the white blood-corpuscles as affecting the particular kind of microbe injected was markedly increased. But as it appeared that the corpuscles were unable to seize their prey unaided, the natural conclusion was arrived at that the microbes had produced in the serum certain antibodies which had enabled the corpuscles to bring about the desired result. These antibodies have received the name of 'opsonins.' This name—selected by Wright and Douglas—is singularly appropriate; it is derived from the Greek *opsonin*, 'to cater for,' the opsonins actually catering and furnishing a relish for the white blood-corpuscles. A normal standard, obtained from the blood of a healthy person, having been fixed for purposes of comparison, the number of microbes seized by the corpuscles in any given case is stated to constitute the 'opsonic index,' the index being high or low according to the number of microbes found within the bodies in question. By the conclusions drawn from these observations certain diseases, notably tuberculosis, are now treated with considerable success by injecting appropriate doses of the offending class microbes, the microbes raising the opsonic index and thus bringing about their own destruction.

An interesting and highly important fact in connection

with this method of treatment is to be found in the frequent fall of the opsonic index shortly after the injection has been administered. This Wright calls the 'negative phase'; it is followed in the ordinary course by a rise, known as the 'positive phase,' and then by a second fall. The existence of the negative phase possesses something considerably more than a scientific importance, and in the present state of our knowledge it may have a direct bearing on the success of military operations. This matter will be referred to later.

From the military point of view the epoch-making event following on Wright's discovery is the introduction of vaccination, or, as it is commonly called, inoculation against typhoid fever, on the lines indicated above. The earlier inoculations in our army were made in the summer of 1899, shortly before the outbreak of the South African War. Wright's suggestion was that of two injections, with an interval of from seven to ten days; but, speaking from personal experience only, I believe that the second injection was scarcely ever carried out at the period referred to. There was a good deal of doubt thrown on the efficacy of the measure, but it is only fair to assume that the absence of the second dose was an important factor in diminishing the good results which it was hoped would ensue. Another material point militating against success was found in the comparatively high temperature—viz., 62° C.—at which the microbes were killed, as this temperature appeared to diminish the contained poison, the presence of which was, of course, essential.

Leishman now destroys the germs at the lower temperature of 53° C., with a decidedly improved result. The vaccine so prepared is called by Leishman the 'new vaccine,' in contradistinction to the 'old vaccine' prepared at the higher temperature ('Statistical Results of Antityphoid Inoculation,' by Brevet Lieutenant-Colonel Sir William Leishman, R.A.M.C., *Journal of the R.A.M.C.*, February, 1909).

The manner in which the vaccine is prepared is interesting, and is excellently described in a paper presented to the United Service Medical Society by Major H. W. Grattan and Captain A. L. A. Webb, R.A.M.C. (*Journal of the R.A.M.C.*,

July, 1909). Briefly stated, the procedure consists in growing an absolutely pure culture of the typhoid bacillus in nutrient broth, and then killing the germs by exposure to a temperature of 53° C. for an hour and ten minutes.

Omitting certain details, the dosage is determined as follows : A measured quantity of the culture is mixed with an equal quantity of blood ; the mixture is next placed under the microscope, and by carefully examining not less than a hundred fields, the numerical relation between the red blood-corpuscles and the germs is determined with the greatest accuracy which is possible. For example, we know that in a cubic millimetre of blood there are about 5,000,000 red corpuscles, and we find, on counting a hundred fields, that there is an average of one germ to five corpuscles. It naturally follows that, provided the quantity of culture equals the quantity of blood, the number of red corpuscles, as compared with the number of germs, must always be in the proportion of five to one. If, for the sake of argument, a cubic centimetre of blood were mixed with a cubic centimetre of the culture, then, as each cubic centimetre contains 1,000 cubic millimetres, and as each cubic millimetre of blood contains—as just stated—5,000,000 red blood-corpuscles, each cubic centimetre of the culture must contain, assuming the above ratio, 1,000,000,000 typhoid germs. We thus know within reasonable limits the number of germs administered on any given occasion. As a matter of fact, Leishman places the number, when given as a preventative, at 500,000,000 germs for a first dose and at 1,000,000,000 germs for a second.

The immediate effects of the injection commonly take the form of a varying rise of temperature, and of pain, with some swelling spreading from site of inoculation. My own experience was not particularly unpleasant. I was inoculated on board ship on a voyage to Durban in December, 1899. The injection was administered at about 4 p.m. ; about 5 p.m. I had a general feeling of malaise, but managed to eat my dinner that night ; at about 9 p.m. my temperature was 102° F., and there was a certain amount of pain extending from

RECENT RESULTS OF ANTITYPHOID INOCULATION.

STATISTICAL TABLE SHOWING THE RESULTS OF ANTITYPHOID INOCULATION IN SIXTEEN UNITS OF THE ARMY UP TO JUNE, 1908.

Unit.	Medical Officer.	Station.	Date of Arrival.	Total Strength (Actual).	Inoculated.			Non-inoculated.		
					Number.	Cases.	Deaths.	Number.	Cases.	Deaths.
2nd Royal Fusiliers ...	Capt. A. B. Smallman	Trimulgherry	Jan., 1905	1,013	198	10	1	815	59	9
17th Lancers	,, E. J. Luxmore	Meerut	Oct. ,,	616	322	3	0	294	71	12
Brigade, R.A.	,, E. G. Lithgow	Pindi (from Transvaal)	Nov. ,,	370	60	0	0	310	7	0
14th Hussars	Lieut. C. E. Fawcett	Bangalore	Oct., 1906	647	386	2	0	261	4	1
2nd Dorsets	,, E. G. Anthonisz	Wellington	Nov. ,,	1,107	199	1	0	908	6	0
3rd Coldstream Guards	,, J. H. Graham	Cairo	Oct. ,,	705	569	1	0	136	13	1
2nd Leicesters	,, H. S. Sherren	Belgaum	,, ,,	963	346	3	1	617	17	1
1st Connaught Rangers	,, A. D. O'Carrol	Dagshai (from Malta)	Mar., 1907	483	300	0	0	183	2	1
3rd Worcesters	,, W. H. Forsyth	Wynberg	Dec. ,,	900	220	0	0	680	3	0
1st Dragoon Guards ...	,, G. H. Stevenson	Umballa	,, ,,	592	450	0	0	142	0	0
1st Yorks	,, S. de C. O'Grady	Cairo	Jan., 1906	893	470	0	0	423	0	0
1st Suffolks	,, J. B. G. Mulligan	Malta	Dec., 1907	900	400	0	0	500	0	0
3rd Royal Rifles ...	,, R. W. D. Leslie	Crete	Feb., 1908	879	190	0	0	689	0	0
2nd Bedfords	,, C. M. Drew	Gibraltar	Sept., 1907	700	320	0	0	380	3	1
Brigade, R.A.	,, A. S. Littlejohns	Pretoria	Nov., 1907	375	247	1	0	128	2	0
1st Lancashire Fusiliers	,, F. D. G. Howell	Chakrata	Dec. ,,	940	796	0	0	144	0	0
				12,083	5,473	21	2	6,610	187	26

CASE-INCIDENCE PER 1,000.

	Inoculated.	Non-inoculated.
1. Among the whole of the above sixteen units	3·8	28·3
2. Among the 'exposed' units—*i.e.*, in which cases of enteric had occurred ...	6·6	39·5
3. 'Exposed' units, *less* Royal Fusiliers (the unit inoculated with the old vaccine)	3·7	32·8

NOTES ON THE CASES OF ENTERIC OCCURRING AMONG THE INOCULATED MEN OF THE SIXTEEN UNITS.

Unit.	Cases.	Deaths.	Remarks.
2nd Royal Fusiliers ..	10	1	All these cases had been inoculated with the old vaccine; no case occurred among the men subsequently inoculated with the new vaccine.
17th Lancers	3	0	New vaccine in all, but each of these men had refused their second dose.
14th Hussars	2	0	Each had two doses of the new vaccine. Both cases were extremely mild; in one the fever only lasted eight days, in the other the maximum temperature was 101° F.
2nd Dorsetshire ...	1	0	Received one dose only of new vaccine; reported as 'exceedingly mild.'
3rd Coldstreams ...	1	0	Twice inoculated with new vaccine; ran a normal course.
2nd Leicesters	3	1	All inoculated with the old vaccine. Of the two which recovered, one was very mild, the other fairly mild. The fatal case only received his second dose one month after the first.
13th Brigade, R.H.A. ...	1	0	Twice noculated with new vaccine. Diagnosis very doubtful, only six days' fever in hospital, blood culture negative, serum reacted to paratyphoid 'B.'

Summary.—There are only *four* cases among the above *twenty-one* which had received two doses of the new vaccine; all recovered. Three of the four had been noted as extremely mild, and the diagnosis of enteric in one of these is doubtful' (*Journal of the R.A.M.C.*, February, 1909).

the seat of inoculation, in the flank, to the axilla. Next day my temperature was normal, and, except for some slight stiffness, I felt perfectly well. I had had enteric fever in Egypt some years previously, and this may have had something to do with my coming off so easily. In some cases the results were more severe. One officer fainted suddenly in the smoking-room, about two hours after the injection; I was close to him at the time, and he fell as if he had been shot, but recovered rapidly under ordinary means of treatment. This happened ten years ago, and with improved means of vaccine preparation, disagreeable symptoms have been greatly modified of late. Recently it has been suggested to administer the vaccine by the mouth, but this plan has not yet been fully investigated. Judging by analogy, there is no reason why it should not succeed, as in the treatment of tuberculosis this means of administering the vaccine—*i.e.*, tuberculin—is widely practised, and with good results.

It would be out of place to discuss at any greater length the complicated details of this method of disease prevention, but those who are particularly interested in the subject would do well to study the masterly articles by Brevet Lieutenant-Colonel Sir William Leishman, F.R.S., Major W. S. Harrison, Major H. W. Grattan, Captain A. L. A. Webb, Captain J. C. Kennedy, and Lieutenant R. G. Archibald, R.A.M.C. (*Journal of the R.A.M.C.*, June, 1900; March, 1905; May, 1907; October, 1908).

The table of results on pp. 23 and 24 has been prepared by Lieutenant-Colonel Leishman.

The results in foreign armies are also worthy of careful study. For instance, at the International Congress of Hygiene and Demography at Berlin in 1907, Surgeon-General Musehold, of the German army, showed that between 1904 and 1907, in a strength of 16,496 Colonial troops, there had occurred 1,277 cases of typhoid fever. Among 1,000 uninoculated men of this force there occurred 98·4 cases of typhoid and 12·6 deaths, while among 1,000 of the inoculated there were 50·9 cases of typhoid and 3·3 deaths. It follows that the man who declined inoculation was about twice as

liable to contract the disease, and four times as liable to die from it. The system has been too recently introduced into the United States army to allow conclusions to be drawn from the results, but the finding of a Board specially appointed by the War Department, and comprising members of the highest professional distinction, is, 'That the practice of antityphoid vaccination is both useful and harmless, and that it offers a practicable means of diminishing the amount of typhoid fever in the army, both in times of peace and war' (Report of Surgeon-General United States Army for 1908, p. 44).

Statistics in regard to Egypt published in the Army Medical Reports for 1907 confirm the favourable results. The 3rd Battalion Coldstream Guards 'arrived in Egypt in October, 1906, and was quartered at Abbassiyeh Barracks, outside Cairo. Between October, 1906, and October, 1907, 14 cases of enteric fever occurred in this battalion. Of these cases, 13 came from amongst the 381 men who had not been inoculated, and only 1 from amongst the 331 men who had been inoculated. These figures are of course small, but we have the advantage in this case of being able to study the incidence of enteric fever in two bodies of men serving in the same locality and under the same conditions, distinguished from each other in no way except by the fact of their being the one of them inoculated and the other non-inoculated' (Army Medical Department Reports for 1907, p. 63).

A leaflet published in India in September, 1909, by the authority of the General Officer Commanding the 1st (Peshawar) Division gives the following information:

'PREVENTIVE INOCULATION AGAINST ENTERIC FEVER.

'CHERAT,
'*September*, 1909.

'In relation to the prevention of enteric fever, inoculation is a measure of first importance.

'The following statistics show the results of inoculation amongst sixteen British corps of all arms during the period October, 1905, to April, 1908:

	Inoculated.	Non-inoculated.
Strength	5,473	6,510
Cases of enteric fever	21	187
Deaths	2	26
Number of cases per 1,000	3·8	28·3

'The figures show that the inoculated man has a much better chance of escaping enteric altogether than the non-inoculated, and if he does get the disease he has a 7 to 1 better chance of getting well than the man who has declined it.

'The case of the 17th Lancers at Meerut is a very striking one.

'The regiment encountered an enteric epidemic shortly after arrival in India. There were 60 cases of enteric altogether.

'Of these cases, 58 had not been inoculated, whilst the remaining 2 had not had their second dose of the vaccine. The men who had been fully inoculated escaped the disease altogether.

'To come closer home, most cases which have occurred in this division for some months past have occurred in un-inoculated individuals.

'These facts are absolutely unanswerable, and the officer or non-commissioned officer who does not use every means in his power to persuade his men to adopt this means of prevention takes on a very serious responsibility.

'The protection afforded against typhoid lasts for at least two years, but the resistance of the blood to the enteric organism remains as high as four times the normal for as long as six years.

'It is not pretended that the method will as absolutely protect against enteric as vaccination will against smallpox, because enteric and smallpox are different types of disease.

'One attack of smallpox is practically an absolute protection against another, but one attack of enteric, although it renders a second attack uncommon, is by no means an *absolute* protection. Antityphoid vaccine may be compared to quinine. Would any individual be justified in withholding quinine from the inhabitants of a malarial country?

Similarly, as in this country, every article of food and drink, and every particle of dust inhaled, is a potential source of enteric, the individual who withholds the weight of his counsel and advice in securing the wide adoption of a method of prevention which has the approval of every scientific mind in Europe and Asia, must have feelings which no one will envy him when he hears that one of his comrades—perhaps his dearest friend—has gone to hospital with enteric fever.'

In fact, the more we study the figures, the more we must become impressed by the results. The procedure is not perfect—nothing in this world is—but we should rate its value by the good obtained, and not by the good we expected.

The question of the negative phase, already briefly mentioned, must not be overlooked. Imagine, for instance, troops embarked for active service, and antityphoid inoculation carried out on board ship. It is not difficult under these circumstances to realize the possibility of men landing in a hostile country with their resisting powers to disease actually diminished, and this at a time when national interests imperatively demand that every available man should be fit to take his place in the firing-line. Musehold, at the Berlin Congress above mentioned, attached considerable importance to the negative phase, but, on the other hand, Leishman has failed to find evidence justifying serious apprehensions in this direction. In the absence of precise knowledge, the soundest plan would be to carry out the inoculations two or three weeks prior to embarkation. It is a matter of regret that, up to the present, men have commonly shown considerable unwillingness to submit to the second inoculation.

It has previously been pointed out in this chapter that the practical application of the principles of immunity is likely to have a far-reaching effect, and will be mentioned later. Vaccines have been prepared against cholera, plague, and, with less success, against dysentery, all of which are closely connected with military service. Reference should also be made to the suggestion as to using for inoculative purposes intracellular poisons derived from the micro-organisms by

mechanical or chemical means. Lustig and Galeotti of Florence have suggested the above as a prophylactic against plague.

Undoubtedly, the most familiar example of artificially produced immunity is that of vaccination against smallpox. There is a certain fundamental difference between the principle of this measure and the principle of antityphoid inoculation, and it is possible that some consideration of this difference may throw light on what has already been said. In vaccination against smallpox we make use of the living germ of the disease modified by passage through the system of the cow, and producing in the latter animal what is known as cowpox, or what is the same thing, smallpox in the cow. In antityphoid inoculation, on the other hand, we do not use the living germ, but a measured quantity of poison produced by the germs, and contained within the dead bodies of the latter, the measurement of the poison being determined by the number of germs used for purposes of injection. In vaccination against smallpox the germ can, so to speak, multiply indefinitely, while in antityphoid inoculation, when once the poison is used up, there is no more to replace it, the dead germs being of course powerless. It follows, naturally, that the protection against smallpox is of a far more lasting nature than that against enteric; the former proves effective for many years, while the latter is of a comparatively transient nature. Competent authorities consider that the protection in the case of enteric lasts for about two years, but perhaps it is safer at present to keep judgment in suspense.

It would be impossible to follow further the multitudinous details of an intricate subject, but perhaps enough has been said to stimulate interest in work which is now being steadily advanced by medical officers of the army, and which is intimately associated with military efficiency, and consequently with national safety.

NOTE.—For further information see 'Inoculation Methods for the Prevention of Diseases to which the Soldier is Liable,' by Lieutenant-Colonel S. Monckton Copeman, M.D., F.R.S., Sanitary Officer 1st London Division Territorial Force (*Journal of the Royal Institute of Public Health*, October, 1907).

CHAPTER III

ENTERIC FEVER

DURING the past few years a mass of evidence has steadily accumulated which goes far to prove that what we have dignified by the above title is certainly not a disease *per se*, but that it is actually a group of diseases caused by organisms closely related to and, to a greater or less extent, mutually convertible among themselves. As the above conception is closely connected with one of the most important branches, if not the most important branch, of military hygiene, it is worth considering with particular attention. The original evidence was in great measure gathered in a somewhat rough-and-ready manner from conditions prevalent during the last South African War; but when the suggestions set forth were found to be supported by laboratory results, what was at one time a mere suspicion soon developed into a strong probability, and is now to a great extent accepted as offering the most reasonable explanation of observed facts. In the first place, it was noticed that enteric fever, so called, appeared again and again in localities where its introduction from without was beyond the range of reasonable possibility, and that its advent had an unmistakable correspondence with the sanitary conditions under which the troops were placed; it was, in fact, clear to all who had experience of service that the longer camps were in occupation the fouler they would certainly become, and as a general rule an outbreak of the disease was merely a matter of time.

For instance, the annual death-rate of the Frontier Field Force in Egypt during 1885 was 28·70 per 1,000, and in 1886 it rose to 70·31 per 1,000. Although these figures comprise mortality from all causes, it is absolutely certain that the vast majority of deaths resulted from enteric fever.

The principal stations occupied by the force consisted of Assouan, Korosko, and Wady Halfa, and the strength during the years in question was approximately constant. Bearing the latter fact carefully in mind, the following figures, although not actually comprising two annual periods, are sufficiently striking, and go far to corroborate the significance of those already set forth :

Number of Cases of Enteric Fever, and Number of Deaths from the Same.

	Cases.	Deaths.
1885.		
Assouan	28	8
Korosko	16	6
Wady Halfa	24	6
1886.		
Assouan	276	97
Korosko	28	16
Wady Halfa	98	37

I served at each of these stations at one time or another during the period named above, and I can state with absolute certainty that the general conditions of comfort during 1886 were an enormous advance on those obtaining in 1885. During the last-named year the troops were mostly under canvas ; the latrines consisted merely of trenches; and water was either drunk straight from the Nile or else after oozing through the interstices of a filthy earthenware 'chatti,' called by courtesy a filter. Towards the latter part of the year the general conditions greatly improved—mud-huts roofed with palm-branches replaced the tents ; buckets and disposal of

excreta outside the limits of the camps replaced the more primitive system; drinking-water was boiled; and, in short, a careful system of general conservancy was maintained.

The new era was, unfortunately, most disappointing in its results, as its advent had a general correspondence with an outbreak of enteric fever, which may fairly be described as terrific. It will be seen by reference to the above figures that the incidence of the disease was least severe at Korosko; as a matter of fact, the cases followed each other at this station with such an appalling and uncontrollable rapidity that had the British battalion in occupation not been withdrawn comparatively early in 1886, the unit would not only have become non-effective, but actually non-existent, before the end of the year, and this at a station which twelve months previously had been officially reported as being 'exceedingly healthy.'

It is an interesting and instructive fact that, at stations where the conditions of life were of the most primitive character, but which had not been long occupied, the standard of health left little to be desired; while, at the same time, the beginning of a serious epidemic was steadily making itself felt at stations where sanitary administration was as perfect as official zeal and energy could make it, but where prolonged occupation under service conditions had resulted in an unavoidable saturation of the soil with organic filth.

It has been stated that enteric fever was prevalent among the native inhabitants of Upper Egypt and the Soudan. This, I am convinced, is an error, partly because, although constantly in contact with the natives, I never saw or heard of a case amongst them, and partly because the whole population would have been obliterated years ago had our sickness-rate been any indication of a state of affairs normally existing. The natives were free at a time when we were suffering severely, and an easy explanation of their escape is found in their practice of getting rid of fæcal refuse by the common-sense expedient of putting it into the Nile, instead of leaving it to fester at their doors; while the fact that we refrained from the above course could not possibly have

made any material difference to the purity, or otherwise, of a stream which formed a sewer for a district stretching northwards from the mountains of Abyssinia to the sea.

Experience gained during the recent South African War is in great measure of the same nature as the above, and even at the risk of some repetition I would venture to call attention to certain circumstances attendant on the incidence of the disease in the army in Natal in 1899-1900.

On January 9, 1900, the Fifth Division left Estcourt to join the remainder of Buller's army at Frere. The sanitary conditions at Estcourt had been none of the best, but since the time of the arrival of the division in December the health of the men had remained fairly good. Diarrhœa was prevalent, but the cases were not severe; I saw none in hospital. I knew of one case of enteric fever in December, but as the man had landed from England on the 23rd of that month, the infection could not very well have been contracted locally. The weather was changeable and tempestuous; rain fell in torrents; the ground was, generally speaking, a morass; the water was turbid, and deposited a copious sediment, and I never heard of boiling or filtration. The march, which, as just stated, began on January 9, was sufficiently trying. Camp was struck in the small hours, the rain had put out the fires, and, as far as I am able to form an opinion, those who got anything satisfactory to eat were in the minority. The division reached Frere about 6 p.m. As greatcoats were not worn, the men were soaked to the skin; they were also badly in want of food. In the case of my own unit the rations were uneatable, as the meat had been recently killed, and, unfortunately, we had no mincing-machine. We marched next day at noon, and, owing to the condition of the ground and the number of waggons, we only succeeded in covering sixteen miles in thirty-six hours. It rained again in torrents; it was bitterly cold by night, and correspondingly hot by day. Guns and waggons stuck repeatedly, and the force crept slowly forward until a halt was made about midnight on January 11, at Springfield Bridge. Progress after this was still slower, and

the head of the column can scarcely have reached the Tugela earlier than the 17th.

Since the Fifth Division had reached Estcourt (the troops arrived between December 24 and December 27, or possibly a day or two later) the men had been exposed to constant changes of temperature, they had been repeatedly soaked to the skin, they had drunk water from any obtainable source, and they had been called upon to make a march which was in itself sufficient to account for a long sick-list. As a matter of fact, but speaking only from my own experience, there was no serious indication of disease in the force before the final days of January.

By this time certain areas of veldt, which had been successively occupied by concentrated bodies of troops, had become seriously fouled. On one of the areas, where concentration had been excessive, known as Spearman's Plain, sickness was particularly severe. It is remarkable that the men of the Naval Brigade, and those of the heavy Batteries of the Royal Artillery, escaped almost entirely. These units were posted on elevated positions on Schwartz Kop and Mount Alice, and the area they occupied was practically unrestricted, as compared with the numbers present. I must, at the same time, admit that this corroborative evidence is prejudiced by the fact that I have no official information as to the strength present.

The appearance of diarrhœa and fever was the first indication of an epidemic, and there is no doubt that many of the cases proved to be genuine enteric. If the water-supply or other local condition caused the outbreak, it is a remarkable circumstance that the latter did not appear sooner. Taking the average incubation period of enteric fever as being ten days, and placing the beginning of the epidemic, for the sake of argument and simplicity, on January 27, it is evident that the men who arrived at Estcourt on December 25 must have drunk the water there with impunity for at least fifteen days. Neither is it likely that the water consumed on the march could have caused the disease, unless a long incubation period is assumed; while, on the other

hand, the incubation period might reasonably be expected to be shortened in the case of men who had swallowed contaminated water when suffering from hunger, exposure, and exhaustion.

From information kindly supplied to me by Dr. Hill, Medical Officer of Health for Natal, there were no cases of enteric fever notified from the area of the relief operations in the neighbourhood of the Tugela in 1902 (this was the first year of notification throughout the colony), and in 1903 the only case notified was one at Colenso, about twenty miles or more from the scene of active hostilities on the Tugela, in January, 1900.

All evidence, indeed, goes to show that the inhabitants of that region of Natal which was the seat of hostilities in the winter of 1900 had been singularly healthy previous to the advent of the war.

It has been suggested that infection originated in cases which had been contracted in the towns, where the disease was known to be prevalent—possibly Pietermaritzburg—or Estcourt. The numbers almost simultaneously attacked render this theory untenable.

'Carriers' have also been suggested as originating the outbreak, but, as in the case above, the simultaneous and widely-spread incidence of the latter throughout the force is inconsistent with the possibility of such a source.

If, as it seems only reasonable to assume from the above, the origin of the sickness was not to be found in endemic causes, it must have resulted from circumstances connected with the troops themselves. The accumulated evidence of military experience proves that, as a broad rule, camping-grounds, even in the healthiest districts, become, under the influence of prolonged occupation, hotbeds of epidemic sickness. The first warning of danger is usually the advent of fever of an anomalous type, lasting a few days, and commonly accompanied by diarrhœa. This condition was formerly called 'simple continued fever.' The cases gradually become more severe, until ultimately genuine enteric fever makes its appearance.

Reserving, for the sake of simplicity, the designation of 'enteric fever' for the condition which is generally held to be casually relative to the *Bacillus typhosus*, a possible explanation of the above facts may be as follows:

In most standing camps in the field those vital agencies of the soil which convert the waste products of organic life into harmless and useful matter can have small chance of satisfactorily performing the functions which Nature has assigned to them. Experience gained from various methods of sewage disposal makes it clear that these organisms must, like other workers, have their task proportioned to their powers, and that they require a due share of rest. If these two conditions can be fulfilled, all goes well, and there is evidence that, under natural conditions, the organisms of a fertile soil are able, in the presence of growing vegetation, to rapidly destroy the intestinal bacteria which are presented to them as accompaniments of sewage or other forms of manure. That the last-named forms disappear is certain, although the precise cause of their disappearance may not be definitely known.*

In a camp on service, however, the concentrated nature of the material to be dealt with, and the constant additions which it receives, together produce a task which the purifying agencies of Nature, in the way of soil bacteria, are quite unable to accomplish, and there consequently results a residue of unaltered, or partially unaltered, material in which the normal intestinal germs seem able not only to thrive, but also to acquire pathogenic properties. Or it might even be that when the change from organic into inorganic is successfully effected, the resulting basic nitrates, if in excess of what is required for plant-life, may likewise form a suitable medium for microbial growth.

Considering the general sanitation of a camp on service, when the soil is fouled with the soakage of latrine trenches with the urine of men and animals, with slop-water, with

* According to the official report published in June, 1899, of the Jardin Modèle at Gennevilliers, about 99·9 per cent. of bacteria in the sewage disappear in the soil (see chapter on Refuse Disposal).

scraps of food and kitchen refuse, and with litter from the transport lines; and when, in addition, the insanitary manner in which food is commonly consumed in the field is remembered, there is no difficulty in perceiving the certainty of the constant entrance into the persons of the men of those bacterial forms which have just been mentioned. It might be expected from the above that the fouler the soil of any camp, the greater the incidence of disease, and this is exactly what experience bears out. The converse of this proposition is equally true, and most officers of experience in the field can state instances of camps where the scrupulous removal of all refuse has resulted in the almost complete absence of enteric or its modifications.*

Besides the evolution of the enteric germ in the soil, it may readily be conceived that a similar evolution may take place in the alimentary tract. It is a matter of common knowledge that the contents of the part in question must be subject to constant chemical changes of a highly complex nature, and in view of what we know of the general laws of life, it is reasonable to infer that such changes cannot be without effect on the bacteria present, many of which latter bear a close resemblance to the typhoid germ. Certain sporadic cases which come within my experience give some support to the above theory: A clergyman who was in a debilitated state of health, the result of long parish work, undertook to investigate, before breakfast, the sanitary arrangements of a parishioner's house, and was consequently exposed, under unfavourable conditions, to the emanations of an exceptionally foul drain. He shortly afterwards developed enteric fever, which proved fatal. The town was absolutely free from the disease at the time, and remained so nearly two years after the occurrence.

In the same locality, but four years previously, and at a time when no other cases of enteric fever were in existence,

* Tyger Kloof in the spring of 1902 was a model of what camp sanitation should be. The 2nd Battalion of the East Yorks Regiment was in occupation. Excellent results were obtained in the face of extreme difficulties. Other exceptionally healthy camps were those at Olivier's Hock and Olivier's Pass, both occupied by the Manchester Regiment.

the daughter of the parish overseer contracted a fatal attack of the malady. The sanitary arrangements of the house were most defective, and the father informed me that his daughter habitually spent 'hours' in the water-closet, engaged in the perusal of works of fiction. The other inmates of the house remained free, and no more cases followed in the general population.

The wife of a non-commissioned officer in a West Indian station developed enteric fever in the married quarters of the military hospital. As far as negative evidence can prove anything, she had not been subjected to any of the usual causes of infection, and she had not left the quarters for nearly a month before the attack occurred. There was, however, frequently a sickening odour from refuse of all sorts which had collected about the habitations of the low-class native population in the vicinity. The woman was a constant sufferer from dyspepsia, which is a circumstance worth noting. No other case either preceded or followed which could reasonably be connected with the one in question. The attack was one of great severity, and terminated fatally in the second week.

A young woman, aged twenty, a resident of one of the healthiest and one of the most elevated parts of St. Helena, developed enteric fever after a visit to relations in Jamestown. The house was in bad sanitary condition, and the water-closet communicated almost immediately with the sewer. The colonial surgeon who attended the patient, and who had been resident in the island practically all his life, informed me that there were no other cases amongst the civil population at the time, nor did any subsequently occur for many months. This was a mild case, and ended in complete recovery.

The reason of the apparently selective action of the *materies morbi*, whatever it may have been, may possibly be explained on the ground that the contents of the intestinal tract are, as already stated, constantly varying in their chemical constituents, and that only certain combinations are favourable to the change suggested. In all these cases

the condition of the alimentary canal may have prepared the way for a change in microbial life, which change was finally effected by the inhalation of certain fœtid emanations. The existence of prolonged indigestion in the last case but one is of particular interest in connection with the possible results of a disordered intestine on the contained bacteria.

A soldier in St. Helena, who had not left the barracks for some weeks, contracted enteric fever and died, the remainder of the troops being absolutely free from the disease. The man had led an unhealthy sort of existence, taking no exercise, and spending many hours of the day in a small and stuffy room.

In December, 1899, a soldier who had certainly not been in South Africa a week developed enteric fever. He had just spent four weeks on board ship during the voyage from England, and no case of the kind during this time had occurred amongst the men.

A European soldier stationed in the fort at Delhi contracted enteric fever in April, 1904. He had arrived in Delhi on March 1 of the same year, and since arrival had on one occasion only partaken of any kind of refreshment outside the fort, when he bought a bottle of soda-water from a native, three days before he reported sick. There were no other cases of enteric fever amongst the British troops, and every precaution was taken in connection with the preparation of mineral water and the sale of perishable goods generally. There was, it is true, a suspicious case in the person of a Pathan soldier of the 28th Punjabis; but even admitting that the man last referred to was actually suffering from enteric fever, there was no reasonable ground for connecting the two cases, as the men of the native regiment were constantly in a part of the bazaar which was never frequented by British troops; in addition to which, careful investigation left little doubt that in the case of the European soldier the disease was not contracted through any of the usual channels. It is possible that the disease may have resulted from contaminated dust, but this is unlikely, for if the trouble had originated in a cause which may be presumed to operate so widely as the

above, other cases would in all probability have occurred amongst the remaining troops in barracks. As in one of the cases previously mentioned, the man was a sufferer from obstinate dyspepsia.

Contrary to what is too often the case, the conclusions arrived at by the observation of clinical conditions are corroborated by laboratory experiment.

In the first place, it is certain that a group of organisms exists of which the various members form what may be termed an ascend-scale of pathogenicity—*i.e.*, disease-producing power, ranging from a normal intestinal inhabitant of man and other animals to what is believed to be the vital cause of what we call enteric fever. Before going farther, it is important to note that even the germ mentioned above as normally existing in the intestinal canal has been found capable of producing a disease difficult, or even impossible, to distinguish from conditions resulting from the germs placed at the opposite end of the scale.

It should be explained that the different members are, broadly speaking, of intestinal origin, and comprise the *Bacillus typhosus*, *B. fæcalis alcaligenes*, varieties of the *B. paratyphosus*, and the *B. coli*, the last-named being the form referred to as normally present in man and other mammals.

The medical history of the South African War, and particularly the brilliant work done by officers of the R.A.M.C. at Roberts' Heights, has thrown a flood of light on the difficult subjects of pathogenicity and mutual relationship of the members of this group, and it is difficult to over-estimate the value of these investigations in their probable effect on the subject of army sanitation. Thanks to the work done by Lieutenant-Colonel C. Birt, Major J. C. B. Statham, Major J. G. McNaught, and others, it is now commonplace knowledge that an uncertain but large proportion of cases which in former years would certainly have been diagnosed as enteric fever are due to infection by the *B. fæcalis alcaligenes*, the *B. paratyphosus*, or the *B. coli*.

The general line of investigation consisted of testing the blood of fever patients as to agglutination on strains of one or the other of the above-named organisms, but it is, however, only fair to state that brilliant pioneer work in this direction had been carried out early in the present century in the United States and Germany.

As bearing on the original investigations, the following extract from the *Journal of the R.A.M.C.* for July, 1903, is well worth careful perusal. The extract in question reads as follows:

'One of the most striking features of modern literature upon enteric fever is the development of the idea that many of the cases which are clinically diagnosed to be enteric, and presumably caused by infection due to the bacillus of Eberth and Gaffky, are really instances of infection by the colon bacillus, or possibly by both it and the *B. typhosus*, has gained ground, and is to some extent supported by scientific evidence. Certain cases reported by Burch in the *Medical Journal* of New York, May 31, 1902, to some extent bear out this view. His patients all suffered from continued fever, preceded by malaise, and invariably accompanied by some gastro-intestinal disturbance. The tongue was dry and foul, the abdomen usually distended, with gurgling and pain in the iliac fossa. Headache and mild delirium were not unusual. Examinations of the blood showed a diminution of leucocytes, while the urine swarmed with *B. coli communis*. With the Gruber-Widal reaction the patient's serum failed to specifically affect the *B. typhosus*, though it did agglutinate the urinary bacilli. None of the cases, apparently, terminated fatally. Many medical officers in the army are familiar with cases of the kind. Clinically and pathologically, they are indistinguishable from classical enterica, but bacteriologically they are not, as the sera are specific only to colon bacilli, while from the spleen and blood only these micro-organisms are recoverable. It is difficult to see why these cases should not be regarded as instances of a pure infection by the colon bacillus, for it is exceedingly improbable that all these should fail to react

to the enteric bacillus if in reality they were cases of typhoid fever.

'Similar in nature, and equally interesting, are other cases which have been recorded in recent medical literature, in which the infecting agent would seem to be organisms intermediate between enteric and the colon bacilli, and which are variously termed paratyphoid or paracolon, according to whether they conform culturally to one or other type.

'There can be little doubt that in the detection, noting, and bacteriologically observing of cases of this kind, especially in India and South Africa, there is a large and promising field of work for army medical officers.

'The line of inquiry should embrace not only exact identification of micro-organisms recoverable immediately after death, but serum reactions of the patient against typical enteric bacilli, typical colon bacilli, and atypical varieties of both. At the same time, when the circumstances permit; the search should be made for bacilli in the blood, and precise identification established of any bacteria found. Some important work in this direction has been done by Cole (*Bulletin of Johns Hopkins Hospital*, July, 1901) and by Schotmueller (*Münch. Med. Wochenschrift*, September 23, 1902), who both find the diagnostic and prognostic uses of bacteriological blood examinations more valuable than the Gruber-Widal test, since the former is able to allow of definite conclusions being formed before the latter. As compared with a bacteriological examination of the fæces or of the spots, the blood method has advantages. The front of the arm must be carefully washed with soap and water, then with ether, and lastly with bichloride of mercury solution (1 in 1,000). The bichloride is next carefully removed by means of sterile swabs of wool soaked in sterile water, and 10 c.c. of blood removed by inserting the sterile needle of a sterile syringe into a superficial vein. The contents of the syringe are quickly passed into agar which has been made fluid and cooled to 45° C., and the whole well mixed and plated. About 2 c.c. of blood should

be added to each tube containing from 6 c.c. to 10 c.c. of agar. Besides the two observers named above, Courmont and Busguet speak well of this method, and, provided elementary care as to antisepsis be observed, it should present no risks to the patient incommensurate with its real diagnostic value.'

It would lead too far from practical consideration to discuss this matter in greater detail; but those who wish for further information cannot do better than study Major Statham's article on the 'Complex Etiology of Typhoid Fever,' which appeared in the *Journal of the R.A.M.C.* for October, 1908, and which sets forth in a masterly manner the relationship of which mention has been made. With the object of presenting a general aspect of the matter in a graphic form, I have introduced the table which appeared in Major Statham's original article, and which should serve to impress the wide possibilities attaching to the group in question.

It being outside the realm of reasonable doubt that such interrelationships as those now in question actually exist, it now remains to be seen as to whether the laboratory yields evidence of mutual convertibility or otherwise.

It is here satisfactory again to be able to allude to the brilliant work of an officer of the R.A.M.C., Captain A. B. Smallman. This officer injected pure cultures of the enteric bacillus into the peritoneal cavities of 200 guinea-pigs, and found after the death of the animals that in no less than 11 per cent. paratyphoid organisms only were present, thus proving that a change of organisms, such as that suggested, must actually have taken place (*Journal of the R.A.M.C.*, vol. v., p. 137).

Further evidence can be found on p. 65, Army Medical Report for 1907, in which report the Specialist Sanitary Officer for Gibraltar (Major Horrocks), in connection with an investigation in regard to an outbreak of enteric fever, raised the question as to whether an organism of uncertain nature 'might eventually be converted into a specific microbe.' In this connection also Dr. Louis Parkes writes as follows:

TABLE SHOWING THE CHARACTERISTICS OF THE TYPHOID-COLON GROUP. (STATHAM).

Name of Organism.	Pathogenic Effects upon Man.	Morphology.	Cultural Reaction.			Agglutination.	Various Animal Hosts.
			Litmus Milk.	Neutral Red Glucose.	Mannite Solution.		
Bacillus fæcalis alcaligenes ...	Has induced conditions indistinguishable from classical typhoid	All of these bacteria are short motile rods. Paratyphoids are more actively motile than the typhoids. They are readily stained by aniline dyes, but do not retain the stain in the method of Gram	Blue	Unchanged	Unchanged	In the case of these bacteria there is usually marked agglutination with the serum of a man or animal suffering from the diseases produced by them (specific agglutination). They are also agglutinated to a much slighter extent by the blood sera of men or animals suffering from diseases produced by the other bacteria of the typhoid colon group (group agglutination)	Man
B. typhosus	Most commonly induces typhoid fever; may cause abdominal symptoms without fever or *vice versâ*; has induced conditions simulating sore-throat, bronchitis, pneumonia, hepatitis, cholecystitis, appendicitis, meningitis, general local affections, such as abscesses, middle-ear diseases, adenoids, etc.		Unchanged or but slightly altered	Unchanged	Acid, no gas		Has been found in splenic abscesses in cows, also in tissues of men, oxen, and cattle
B. paratyphosus A	May induce a condition clinically indistinguishable from typhoid fever. The cases, however, are mild. Postmortems show the patches of Peyer not affected, and mesenteric glands and spleen less enlarged than in typhoid		Turned a permanent pinkish	Gas is evolved and slight fluorescence, disappearing in a few days	Acid, little or no gas		Man, cattle, sheep, dogs, and pigs
B. paratyphosus B .. ... Meat-poisoning bacilli *Group A.* Aertyck, Meirelbeck, Serault, Gunther, Calmphout, Smith *Group B.* Gärtner, Morceilli, Brussel, Gent, Brugge, Rumfleth, Haustadt *Hog-cholera Group.* *B. morbificans bovis* (calf septicæmia) *B. typhi murium* *B. psittacosis* *B. paracoli*	Produce either an acute gastro enteritis or a condition clinically indistinguishable from typhoid fever Both varieties may occur in the same epidemic		Turned first red (acidity), later a deep blue (alkalinity)	Much gas and marked permanent fluorescence	Acid and gas		Man, cattle, sheep, dogs, and pigs Found in the meat of pigs, oxen, sheep, etc.
B. coli	May produce typhoid fever or enteritis		Turned red and coagulated	Very much gas and marked fluorescence	Acid and much gas		Man, most mammals

'What the exact relationship is between the true *B. typhosus* and the paratyphoid group; whether, under any circumstances, outside the human body, there can be a change of type of *B. typhosus* into a paratyphoid organism and ultimate reversion to the *B. coli communis*, with partial or complete loss of parasiticism, are questions which do not at present admit of any answer. The mere fact, however, that enteric fever is not always dependent on a special micro-organism, but can be apparently produced by an allied group of organisms, capable of differentiation by appropriate cultural tests, is highly suggestive of those possibilities of variation, modification, and reversion in type under different environments of host, soil, and climate, which are consistent with the natural laws of evolution of species' (Louis Parkes, M.D., D.P.H., 'House Drainage and Sewerage in Relation to Health'). It here may be useful to pause and review the ground over which we have travelled.

We know that the members of a group of organisms—conveniently called the typho-colon group—are able to produce diseases clinically indistinguishable one from another, and only to be differentiated by the agglutinative power of the blood on the causative microbe; we have evidence that the members of the group are to a greater or less extent interconvertible; we know that one member, at least, of the group—viz., the *B. coli*—is a normal inhabitant of the alimentary canal of man and of most mammals; we know that, owing to defective conservancy, but oftener to unavoidable causes, such as the presence of transport animals, the last-named organism is likely to be ubiquitous in most camps under conditions of war service; we know that the diseases in question are constant accompaniments of camp-life under the condition just named; and, lastly, we know that the same diseases are likely to occur in individuals suffering from a disordered state of the intestinal tract.

Reviewing the above facts, we shall not be far wrong in our efforts at prevention if we bear constantly in mind the alarming potentialities of *B. coli*, regard the germ in question as the 'root of all evil,' and deal with it accordingly; in

short, we may, for practical purposes, consider the whole of this group of germs as consisting of the above-named, together with its pathogenic varieties.

Reduced to practice, efforts at prevention largely resolve themselves into a strict system of conservancy, comprising the removal or destruction of all matter in which *B. coli* is naturally contained—viz., the excreta of men and animals—and the like destruction or removal of all matter in which the bacillus is likely to find a suitable breeding-ground. It has been pithily observed by a no less eminent authority than Major E. L. Munson, United States Army, that 'the excreta must be removed or destroyed, or the soldier must be removed or he will be destroyed'; and this aphorism might well be extended to embrace putrefactive matter in general, for there is no doubt that the general refuse of a camp in the shape of slop-water, fragments of food, etc., all contribute towards a disastrous result.

The actual measures comprised in the term 'conservancy' are considered elsewhere under their respective headings. There is, however, one measure in connection with the above which should be discussed at present; it is the frequent change of camping-ground when occasion allows, and this opens up the question of the saprophytic existence of the typhoid bacillus and other germs of the same group. It was formerly held that these germs were able to exist indefinitely in soil and water; but this view is now practically abandoned, and the valuable work of Major J. C. Morgan and Captain D. Harvey, R.A.M.C., in connection with soil, and that of Dr. A. C. Houston in connection with water, have gone far to put an end to a delusion totally contrary to the findings of common sense and daily experience; at the same time, it is clear that the life of the organism must be in great measure determined by the chemical nature of the soil, moisture, temperature, and other factors, many of which are of a highly uncertain nature.*

* 'An Experimental Research on the Viability of the *B. typhosus* as excreted under Natural Conditions by the Chronic Carrier," by Major J. C. Morgan and Captain D. Harvey, R.A.M.C. (*Journal of the R.A.M.C.*,

Considering that since the dawn of time the soil must have been the usual destination for excretal matter, and assuming the correctness of the abandoned views, it is rather hard to see how the human race in its present form can ever have come into existence.* The opinions of Koch in connection with the saprophytic life of the germ are also well worth quoting; they are clearly set forth in the following extract from one of his reports as translated by Major F. F. Russell, United States Army:

'Typhoid bacilli were said to be able to live a long time in water, and if they got on to the earth they could penetrate into it and multiply there; that they could live for decades and possibly centuries, so that if a soil infected in this way was cultivated or disturbed typhoid broke out. Yet the longer I have busied myself with typhoid etiology, the more I have receded from this conception. The first thing that I became convinced of was that typhoid bacilli are not able to live long in water. Indeed, it not infrequently happens that a well is infected, and a number of persons round about sicken. I have often had occasion in such cases to have the water examined, but so far as I remember at this moment we have only succeeded a single time in demonstrating typhoid bacilli in a well; that was only because fresh fæces were being continually washed into it. This brought me to the conclusion that the relation of typhoid bacilli to water was quite a different one from what we had formerly believed. Quite in the same way, I have more and more come to believe, with reference to the soil, that typhoid

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June, 1909); Second and Third Report on Research Work for the Metropolitan Water Board, by Dr. A. C. Houston.

* The use of night-stools, with subsequent deposit of the contents in the soil, began to disappear in England about the close of the eighteenth century. Water-closets first made their appearance about this time; they were subsequently introduced into France by certain of the higher clergy, and were there looked on as highly interesting novelties. It is certain that up to the outbreak of the French Revolution the introduction, and subsequent removal, of the *chaise percée* during the progress of the royal toilet ranked among the privileges of a proud and ancient nobility (Taine, 'Origines de la France Contemporaine').

bacilli cannot long hold out there. Perhaps in a moist soil in the presence of excrementitious matter they may be able to survive a couple of weeks, or, at most, a few months. It is possible that when they are spread on a field with manure they may be able to outlast a winter. If one studies a small typhoid epidemic in which the sources of infection can be traced, it is found that the single cases bear a certain relation to one another.

'They commonly form chains—that is, one case depends upon another—and one can follow the direct transmission of the disease from person to person. We must therefore come more to accept the idea for typhoid, as for cholera, that the bacilli are obligatory parasites, which cannot long survive outside the body, although they may hold out somewhat longer than cholera vibrios, especially in the soil' (*Veröffentl. a. d. Geb. d. Mil. San., Wes. Berl.* Heft. 21).

The removal of a camp from any given locality allows the vital agencies of the soil to carry out their beneficent rôle of destroying intestinal germs. The time required for one class of bacteria to destroy the other depends on many factors, such as nature of soil, presence or absence of vegetation, etc., so that it is not possible to lay down precise rules; the question is certainly one of great importance, because where land is restricted in quantity it may be necessary to return to an abandoned site.

Perhaps a good working rule would be to avoid an old site as long as any signs of gross contamination were present. The safest rule is never to occupy an old site, but this is rather a council of perfection. Besides strict conservancy, the necessity of maintaining a healthy condition of the alimentary canal must not be forgotten. The two main factors in attaining this object are suitable food and suitable clothing; the necessity for the first is obvious, and the necessity for the second is found in the fact that chill, by causing contraction of the surface bloodvessels, may result in serious congestion of the internal organs, while the use of woollen clothing—including the cholera belt—checks the passage of heat from the body, and thus acts as

a sufficient protection against this form of danger. It is highly interesting to note that French military surgeons have seriously considered the question of a possible conversion of the *B. coli* into the *B. typhosus* taking place in the intestine, the determining cause of the change being either over-fatigue or the foul air of an overcrowded barrack-room. It will be remembered that cases suggestive of the influence of foul air have already been mentioned in this chapter.

In this connection the subjoined extract, which I have borrowed from a note in Dr. Lachaud's 'Notre Soldat,' will repay careful study. The views incidentally expressed in regard to 'carriers' are scarcely in accordance with our own ideas:

LE BACILLE D'EBERTH, LE SURMENGE ET L'ENCOMBREMENT DANS L'ÉTIOLOGIE DE LA FIÈVRE TYPHOÏDE.

PAR DR. NOEL

(*Bulletin Médical*).

La connaissance du rôle joué par le bacille d'Eberth dans la genèse de la fièvre typhoïde a eu des conséquences très heureuses pour la prophylaxie de cette affection, notamment en mettant en évidence l'action de l'eau de boisson. Malheureusement, quelques esprits ignorants ou oublieux, ont été hypnotisés par le bacille, dont ils ont fait la cause unique de la dothiénentérie, et qu'ils poursuivent dans les selles, non seulement des convalescents, mais même des personnes bien portantes. Nous ne reviendrons pas sur certaine circulaire dont il a été suffisamment parlé dans ce journal et ailleurs; mais il n'est peut-être pas inutile—pour montrer l'état d'esprit qui règne en haut lieu—de signaler à nos lecteurs une circulaire (en date du 23 août dernier), très sage en elle-même, car elle est destinée à faire comprendre aux cuisiniers militaires la nécessité de la plus stricte propreté en matière de boucherie et de cuisine, mais où la hantise du bacille se traduit par les phrases suivantes :

'Les personnes qui ont eu la fièvre typhoïde ou d'autres affections similaires (intoxications paratyphiques) ne doivent

pas être employées aux cuisines, en raison de ce fait que l'intestin peut conserver pendant longtemps les germes de ces maladies.

'Il convient aussi de savoir que les agents microbiens en question peuvent exister dans les selles de personnes bien portantes vivant dans l'entourage des malades atteints de ces affections.'

Nous avouons bien sincèrement que nous ne voyons point comment le bacille d'Eberth, refermé dans l'intestin d'un soldat, devient particulièrement dangereux pour l'état sanitaire de ses camarades quand ce soldat fait la cuisine. Il y a là un mystère qui demeure pour nous insondable, et, devant cette phobie du microbe, il est peut-être opportun de signaler que le dogme, qui en est le point de départ, est fortement battu en brèche.

Et c'est pour cela que nous croyons devoir reproduire la remarquable mise au point de la question qui vient d'être faite dans l'Union médicale et scientifique du Nord-Est, par M. le Dr. Téchoueyres. La voici *in extenso :*

NOTE SUR LA PARENTÉ DU BACILLE D'EBERTH ET DU COLI.

PAR M. LE DR. TÉCHOUEYRES,

Directeur du laboratoire de bactériologie de Reims.

Cet exposé, qui a pour objet de définir les rélations du bacille d'Eberth et du coli-bacille, trouve son excuse dans l'intérêt que les médecins et les hygiénistes ont toujours apporté aux questions qui traitent, de près ou de loin, de la fièvre typhoïde. La discussion a été maintes fois ouvertes à ce sujet. Ouvrons-la une fois encore ; il n'y paraîtra guère.

La question se pose ainsi : ces bacilles ont-ils une parenté si rapprochée qu'ils se confondent originellement dans une espèce commune ? Sont-ils, au contraire, à ce point différentes qu'ayant un habitat commun, il soient cependant toujours bien distincts et aisés à distinguer ?

Voilà ce qu'à la lumière de faits nouveaux nous cherchons à éclaircir. Et dès l'abord, exposons le question dans toute

sa simplicité. En 1880, Eberth découvrit dans la rate, les ganglions mésentériques, et les plaques de Peyer des dothiénentériques, un bacille qu'en 1884 Gaffky isola et cultiva ; étudié depuis par Chantemesse et Vidal, il est connu sous le nom de bacille d'Eberth, et généralement réputé pour être l'agent de la fièvre typhoïde.

Quelques années plus tard, en 1885, Escherich isola, dans les matières fécales du nouveau-né, un bacille qu'on retrouva promptement dans l'intestin de l'homme et des animaux ; ce bacille contribue à enricher la flore déjà si dense du gros intestin et, s'il faut en croire Metchnikoff, détermine pour sa part les phénomènes de décrépitude et de vieillissement propres aux vertébrés pourvus, ou plutôt affligés d'un cæcum. Ce germe est connu sous le nom de coli-bacille.

À ses débuts, dans le monde des laboratoires, il fut réputé saprophyte, et, n'étant pas rédoutable, il ne fut pas considéré. Mais voici qu'en 1889 les travaux de Rodet et de G. Roux de Lyon le mirent en lumière. Ces auteurs avaient été frappés des ressemblances qui existent entre le coli et l'Eberth :

1. Ressemblances morphologiques : tous deux présentent la forme de bâtonnets cylindriques très polymorphes, mobiles grâce à des cils, un peu plus nombreux sur l'Eberth ;

2. Ressemblance chimique, si l'on peut ainsi désigner le fait qu'ils présentent des affinités communes pour les mêmes teintures ;

3. Ressemblance physiologiques en ce qui concerne la température du développement, les milieux d'élection et l'aspect des cultures sur les dits milieux.

Sans doute, il est bien quelques dissemblances de détail ; mais Rodet et Roux, ayant, au surplus, démontré qui le coli-bacille est non un saprophyte mais un microbe pathogène, conclurent que le bacille d'Eberth n'est qu'une variété moins résistante, mais autrement adaptée et particulièrement virulente.

La théorie des auteurs lyonnais souleva de nombreuses protestations, et provoqua d'amples travaux. On se mit à l'œuvre pour rechercher les moyens de différencier aisément

les deux germes et de montrer ainsi le mal fondé de la théorie lyonnaise. Les noms de Chantemesse et Vidal, Perdrix, Dubief, s'attachent à cette phase de la question. On fut heureux de trouver que le coli-bacille fait fermenter la lactose et coagule le lait, à l'exclusion de l'Eberth, et que ce dernier est agglutiné par le serum des typhiques, à l'exclusion du coli-bacille. Ces distinctions parurent suffisantes.

Une fois encore la question sembla jugée, et les tenants du dualisme furent triomphants.

Cependant, à y bien regarder, était-ce là une preuve suffisante de la distinction absolue des deux germes ? Alors même que l'un, l'Eberth est considéré comme l'agent constant de la fièvre typhoïde, et l'autre, le coli-bacille, comme un parasite, sans doute nocif mais jamais typhique, ne se peut-il faire qu'ils soient de même origine, de même espèce, et que de simples caractères de variétés les distingent (car on ne saurait oublier qu'ils ont la même forme extérieure, les mêmes affinités colorantes, qu'ils végètent de même sorte sur des milieux indentiques, que leur parenté s'inscrit tout au long de leur vie). Et cette végétalité excluse du coli sur la lactose, qu'il fait fermenter, et cette agglutination aussi exclusive de l'Eberth par un sérum typhique constituent bien les caractères de simples variétés. Le passage de l'une à l'autre forme serait fonction des conditions de milieu réalisées de façon variable par l'hôte ordinaire du coli.

Ainsi d'ailleurs, pourraient s'expliquer aisément les cas sporadiques de fièvre typhoïde. Que le sujet porteur du coli soit en état de moindre résistance ou, du moins, réalise accidentellement les conditions favorables à l'acquisition par le coli de propriétés pathogènes, et la forme éberthienne est créée ; elle se multiplie, dès lors, avec ses propriétés nouvelles, peut, contaminant les eaux propanger l'infection avec les caractères particuliers aux épidémies d'origine hydrique.

Les médecins militaires, qui ont eu fréquemment l'occasion d'observer des épidémies de cette origine, n'ignorent pas, cependant, qu'à la suite des marches forcées, des grandes manœuvres, il survient des cas isolés de fièvre typhoïde pour

lesquels la récherche de l'origine hydrique serait proprement un leurre. Ce n'est pas l'eau, non plus, qu'il faut incriminer lorsqu'au début des fortes chaleurs les infirmeries s'encombrent de ces embarras gastriques ou l'on peut déceler toute une gamme pathologique qui va de la plus légère infection jusqu'aux formes où la recherche du sero-diagnostic est positive et juge la question.

Il semble donc que la clinique apporte ici quelque argument à la théorie uniciste. Mais, dira-t-on, un bon fait bien observé vaut mieux que toutes les théories du monde, et rien ne prouve, *à priori*, que le bacille coli puisse du fait d'une végétation particulière acquérir des propriétés nouvelles.

C'était à l'expérimentation de répondre. La résponse a été faite, mais il semble bien qu'on ne l'ait pas entendue—*Aures habent, et non audient.* En 1889 Emile Laurent (*Annales de l'Institut Pasteur*) a montré que le bacille, qui n'est pas normalement un parasite des plantes vivantes, et en particulier des pommes de terre, devient susceptible de s'y développer énergiquement, si ces mêmes pommes de terre ont été préalablement plongés dans une solution alcaline; il acquiert, par rapport à elles, des propriétés virulentes. Et Emile Laurent insiste sur le fait que, dans les cultures, la diminution de la résistance des végéteaux à leurs ennemis cryptogamiques détermine la transformation des êtres saprophytes en vrais parasites. L'éxample paraît topique et suffit à prouver que le bacille peut devenir virulent par rapport à l'hôte qui l'héberge, lorsque, précisément, cet hôte modifie ses propriétés, et, pas conséquent, sa constitution physico-chimique.

Mais une autre série d'observations devaient accuser encore davantage la vraisemblance de la théorie uniciste. Les deux camps n'ayant pas désarmé, chacun s'attacha à déceler quelques caractères nouveaux propres à l'un des germes ou communs aux deux. On multiplia les cultures; les procédés de recherche furent diversifiés de façon à mettre en lumière quelque propriété nouvelle du germe, et la récompense de tant d'efforts fut de découvrir qu'entre le coli et l'Eberth il existait des germes participant de l'une et l'autre forme, et

paraissant être des intermédiaires et des termes de passage; parmi ceux-ci quelques-un se rapprochaient du coli, quelques autres de l'Eberth. Envisagée du point de vue darwinien, une semblable observation démontrait, autant qu'il se peut faire en pareille matière, le légitimité de la conception uniciste.

Mais le camp adverse ne se tint pas pour vaincu. Animé de cet esprit méthodique, qui range, classe et inventoire, il s'appliqua à décrire ces variétés comme les espèces nouvelles, et croyant fortifier l'idée par un nom, les appela paratyphiques. Puis une distinction nouvelle s'imposa bientôt, on n'hesita pas on décrivit un paratyphique A et un paratyphique B. Ce n'est pas tout encore; d'autres variétés apparurent qui n'étaient ni coli, ni Eberth, ni paratyphique B, ni paratyphique A : ce furent des formes intermédiaires, et c'est en effet sous ce nom, très comprométtant pour la théorie dualiste, qu'on les designe communément aujourd'hui.

Si telle est l'œuvre des seuls laboratoires, nous avons appris, au recent Congrès de Clermont-Ferrand, ce que peut la collaboration de la clinique et du laboratoire. M. Rodet s'est attaché à rechercher toutes les origines microbiennes possibles de la fièvre typhoïde; pas les procédés en usage il isola les germes; il nota les resultants des analyses bacteriologiques, et les compara aux formes cliniques, et conclut: Que le bacille d'Eberth est parent du coli auquel il rattache une multitude de formes intermédiaires; or, Eberth, coli, paratyphique, etc., tous sont typhogènes.

(Sur 37 examens des selles des typhoïsants, il n'a trouvé que neuf fois bacille d'Eberth et vingt-huit fois un grand nombre de bacilles différents, et différents par la culture, par l'intensité d'agglutination, etc.).

Que dans la fièvre typhoïde, les types intermédiaires sont constants, co-existants.

Que les paratyphiques sont très divers et graduellement étagés entre l'Eberth et le coli, et qu'ils abondent dans l'intestin des typhoïsants.

De tout cet exposé, ne semble-t-il pas que—sauf preuve ultérieure du contraire—il n'y a pas lieu de maintenir une différence essentielle entre les deux germes et que l'Eberth

n'est qu'une variété particulière virulente du coli-bacille. Cette variété laisse, en souvenir de sa transformation et comme pour marquer les étapes de sa route, les formes intermédiaires qui sont, à nos yeux, les témoins vivants de cette évolution.

Nous partageons l'opinion de ces médecins militaires dont parle M. Téchoueyres, qui ne croient pas à la constance de l'origine hydrique et cela parce que, dans une vie médicale passée dans l'armée, nous avons toujours vu la fièvre typhoïde provoquée par le surménage ou l'éncombrement, quand ce n'était point par ces deux causes réunies.

Au début de ma carrière militaire, j'ai éte le témoin d'une épidémie de fièvre typhoïde combien suggestive, au point de vue du rôle joué par le surménage. J'étais attaché à un régiment d'infanterie caserné au Château d'Eau. L'état sanitaire était parfait. Le régiment se rendit à Saint-Denis, où il partagea une excellente caserne avec des artilleurs, dont la santé ne laissait rien à désirer. Peu après, au régiment, les malades commencèrent à affluer, les embarras gastriques apparurent, et bientôt on était en pleine epidémie typhoïde, tandis que les artilleurs conservaient leur perfait état sanitaire. Le médecin inspecteur Cazalas, président du Comité de santé, envoyé par le ministre de la guerre pour déterminer les causes de cette épidémie, la rattacha au surmenage eprouvé pas nos hommes, qui étaient de garde un jour sur deux, et allaient à l'exercise en descendant la garde. Il fit réduire le service de place qui écrasait le régiment, et, les hommes se reposant, l'épidémie prit fin, sans qu'on eût désinfecté les chambres, sans qu'on eut évacué le casernement, sans qu'on eut contaminé les artilleurs. *Tollitur causa, tollitur effectus.*

Plus tard, je fus attaché à un bataillon de chasseurs obligé, faute de chambres en nombre suffisant à la caserne principale, d'envoyer dans un fort deux demi-compagnies. De temps à autre je voyais se produire de ces bouffées d'embarras gastrique, caractéristiques des premières manifestations cliniques de l'empoisonnement typhoïdique. Je pouvais affirmer à coup sur que, dans la chambre de ces

malades, des lits devaient être en surnombre par rapport à la contenance réglementaire réelle, par suite de la rentrée irréglementaire de quelques hommes detachés au fort. Jamais mon affirmation n'a été en défaut, et, du reste, il suffisait de ramener la chambre à son effectif réglementaire pour enrayer les cas d'embarras gastrique. Voilà pour l'encombrement.

J'empruente au Caducée (I) le récit d'une épidémic particulièrement instructive, dans laquelle se trouvent réunis tout à la fois le surmenage et l'encombrement, et qui se présente avec toute la rigueur scientifique d'une expérience.

Le 19^e^ bataillon de chasseurs à pied, en garnison à Vincennes—dont l'état sanitaire était excellent—est consigné le 4 juillet 1893 à partir de 4 heures. Il passe la nuit sous les armes, prêt à partir. Le 5, il se rend à la caserne du Château-d'Eau, déjà encombrée de troupes. À 3 heures, il occupait la Bourse du travail. Tout le monde, officiers et soldats, coucha par terre, la nuit du 6 au 7, dans la salle des conférences, et les couloirs qui l'environnent.

(Elle ne tarda pas à être surchauffée au delà de toute expression. La température n'y était pas loin de 40° et, dès la seconde nuit, l'air qu'on y réspirait était absolument infect.) Le 7, on coucha sur des paillasses. (Comme on redoutait surtout les alertes nocturnes, les hommes, de même que les officiers, veillaient presque toute la nuit. Du 4 au 11 juillet, date du retour à Vincennes, personne ne put se déshabillier).

Résultats : 14 chasseurs entrèrent à l'hôpital pendant le séjour à Paris pour diarrhée, embarras gastrique; chez l'un le diagnostic de fièvre typhoïde fut vite établi.

(D'autres cas se produisent rapidement, atteignant à la fois les officiers et les hommes de troupe. Sur 19 atteints, 6 portent sur des officiers, 2 sur des sous-officiers, et 11 seulement sur des soldats. Des 14 officiers présents à la Bourse du travail, 6 furent atteints, soit 43 per cent.; tandis que la troupe ne fut atteinte que dans la proportion de 2·66 per cent.) Les sous-officiers ont été aussi plus atteints que les soldats.

De ces faits, il n'y a pas un médecin militaire qui ne puisse en fournir des quantités. Et c'est pour cela que ceux d'entre eux qui ont vécu de la vie du soldat sont convaincus que, dans la genèse de la fièvre typhoïde dans l'armée, le terrain est la condition importante, primordaile, capitale.

En rentrant de Normandie à Paris avec un régiment d'infanterie, qui avait pris part à des manœuvres fatigantes; qui, marchant par division constituée, n'était pas logé, mais faisait du cantonnement resserré; qui recevait depuis quatre jours une pluie ininterrompue, à tel point que les effets de réchange étaient trempés, j'ai pu prévenir le colonel que nous arriverions avec la fièvre typhoïde—et l'évènement a prouvé mon dire.

C'est que—comme l'a si bien dit mon maître, le professeur Kelsch—quand une troupe sort de la caserne, elle emporte dans la semelle de ses souliers le germe de la fièvre typhoïde, qu'on cultive à volonté.

Pour ma part, j'ai la conviction profonde que la fièvre typhoïde du soldat est due aux bacilles saprophytes de l'intestin, qui deviennent pathogènes sous l'influence de l'auto-intoxication produite par le surménage ou l'encombrement.

Si l'on pouvait obtenir que le chef d'une troupe atteinte d'une épidemie passe devant un conseil d'enquête—ainsi qu'il est fait pour le commandant dont le navire est avarié—et que, s'il a pris sur lui de rejeter les mesures hygiéniques demandées par le médecin, il supportât toutes les conséquences de cet acte on aurait plus fait pour la prophylaxie de la fièvre typhoïde qu'en pourchassant le bacille d'Eberth dans les selles des convalescents et des bien portants . . . même si ce sont des cuisiniers.

Dr. Noel.

Whether the conclusions arrived at are just I would not pretend to say, but as expressions of opinion they are interesting. It is certain that the French soldier does not enjoy the sanitary advantages in regard to air space which obtain in English barracks, and it is equally certain the French Army suffers from enteric fever to an extent which

is quite out of proportion to that existing among our own troops while on home service; for instance, in 1907 the admission rate per 1,000 in the United Kingdom was ·7, and that in France in 1905 was 3·8; while as shown by Dr. Lachaud, in the work named above, the French Army Medical Reports for the decennium 1895 to 1904 reveal 27,230 cases of enteric fever, as against 6,497 cases in the German Army during the same period (Lachaud, 'Notre Soldat,' p. 271).

It may here be objected that, in view of our careful maintenance of adequate cubic space, the question of overcrowding does not concern us. Such an objection is far from valid, as, with the recent expansion of our military system, it is clearly our duty to foresee as far as we can the possibilities which such a system may entail.

If, in spite of all possible precautions in the shape of sound conservancy and the other factors which have been named above, an outbreak of enteric fever or its allies takes place in camp or barracks, it remains for us to consider the means of spread, and the best steps for combating the same. Whether in peace or war the principles are identical, although naturally modified in their application according to the exigencies of the position. The actual routine to be adopted is set forth in the regulations, and it is here only intended to discuss points which do not receive attention in the above.

The most important channels by which the disease spreads are as follows:

1. *Personal Contact.*—It is well known that the infective agent exists in the fæces, urine, expectoration, and sweat, the two former being by far the most important. Infection may be conveyed from patients actually under treatment; by mild or unrecognized cases; and, lastly, by 'carriers'—in other words, by persons who harbour the bacilli without themselves being affected. Such persons are usually convalescents, but are sometimes nurses or others who, having received infection, have never suffered from recognizable results in the form of sickness. It may be stated that up to

the present attention has mainly been concentrated on carriers of the actual *Bacillus typhosus*, but there is no reason why carriers of the other forms should not widely exist.

Infection from the first-named source—*i.e.*, patients actually under treatment—resolves itself into the common-sense measures which form part of hospital administration, but the two last named constitute problems of great difficulty. In the first place, it must thoroughly be grasped that enteric fever, using the term in the sense of a group of diseases, masquerades under a variety of disguises, such as sore-throat, slight diarrhœa, mild febrile attacks, pneumonia, bronchitis, and even appendicitis.

It will be noticed that sore-throat appears first on the list. von Drigalski states that no less than 40 per cent. of cases of enteric fever begin with the above symptom, and that the bacilli can be found on the tonsils (Kolle u. Hetch, Exp. Bakt. Berlin, 1908, p. 190). Although we are justified in doubting the accuracy of this statement, as regards numbers, the fact that such an occurrence is possible sounds a valuable note of warning, particularly to the medical officer on service. Diarrhœa should always excite suspicion. The evidence of the Spanish-American War in this connection has proved of enormous service in drawing attention to a danger which in former years would have passed unnoticed. I would here quote an extract from Dr. Child's 'Study of the Typhoid Fever Epidemics in the United States Volunteer Encampments, 1898' :

THE RELATION OF INTESTINAL DISORDERS TO TYPHOID FEVER.

'With a view to testing to what extent the diarrhœal diseases which prevailed so much throughout all the camps might have been due to slight or abortive typhoid infection, the Board traced out the record and subsequent history of all the cases occurring in 48 regiments, with a mean strength of 55,829 men. The total number of cases of diarrhœa was 9,481.

'There were 7,745 cases of typhoid fever in these regiments,

TABLE SHOWING CASES OF TYPHOID FEVER AMONG THE MEN OF FORTY-EIGHT REGIMENTS OF THE SECOND AND SEVENTH CORPS WITH OR WITHOUT PRECEDING DIARRHŒAL DISEASES.

Camp.	Number of Regiments.	Mean Strength.	Diarrhœal Diseases.		Cases of Diarrhœal Diseases followed by Typhoid Fever.		Number of Men who had no Preceding Diarrhœa.	Typhoid Fever without Preceding Diarrhœal Diseases.		Total Cases of Typhoid Fever.
			Number of Cases.	Number of Individuals.	Number of Cases.	In 100 Men with Preceding Diarrhœa.		Number of Cases.	In 100 Individuals who had no Diarrhœa.	
Alger	19	21,988	5,345	3,894	174	4·4	18,094	1,777	9·8	1,951
Jacksonville ...	7	7,990	2,370	1,877	131	6·9	6,113	1,161	18·9	1,292
Meade	13	15,092	2,048	1,857	179	9·1	13,235	2,198	16·6	2,377
Jacksonville ...	9	10,759	2,056	1,853	164	8·8	8,906	1,961	22·2	2,125
Total ...	48	55,829	11,828	9,481	648	6·8	46,348	7,097	15·3	7,745

TABLE SHOWING CASES OF TYPHOID FEVER AMONG THE MEN OF FOUR REGIMENTS OF THE SECOND ARMY CORPS (TAKEN AT RANDOM), WITH OR WITHOUT PRECEDING DIARRHŒAL ATTACKS, JUNE DIARRHŒAS EXCLUDED.

Regiment.	Mean Strength.	Cases of Diarrhœal Disease.		Cases of Typhoid Fever with Preceding Diarrhœa.		Men not having had Diarrhœa.	Cases of Typhoid Fever without Preceding Diarrhœa.		Total Cases of Typhoid Fever.
		Number.	In Individuals.	Number.	In 100 Individuals with Diarrhœa.		Number.	In 100 Individuals without Diarrhœa.	
3rd Missouri	1,168	364	331	2	0·6	837	82	9·7	84
7th Illinois	1,203	289	247	2	0·8	956	40	4·1	42
13th Pennsylvania ...	795	281	221	6	2·7	547	77	13·4	83
3rd New York	1,261	317	260	4	1·5	1,001	137	13·6	141
Total	4,437	1,251	1,059	14	1·4	3,368	336	9·9	350

and from the data obtained by the Board it was shown that the incidence of typhoid amongst those who had not been reported for diarrhœa was more than twice as great as the incidence amongst those who had been reported sick with diarrhœa.

'These results plainly indicate that the attacks of diarrhœa referred to conferred a certain amount of immunity from typhoid, and that a considerable proportion of the cases of diarrhœa were in reality cases of abortive or ambulant typhoid.

'The Board considered that the attacks of diarrhœa which occurred in June (*i.e.*, during the second month of encampment) were due to errors of diet, etc., were not connected with the subsequent typhoid, and did not confer any immunity. The diarrhœas of July and August (*i.e.*, just preceding and accompanying the typhoid outbreaks) appeared to be most intimately related to the typhoid, and it is important to note that in four regiments, selected at random, the cases which had had diarrhœa in July and August were seven times less susceptible than those who had not had such diarrhœa.

'"An examination of the foregoing table will show that the men who suffered from diarrhœal attacks during these months when typhoid fever was prevailing at Camp Alger, Va., were seven times less liable to contract typhoid fever than those who had had no diarrhœa. Taking the total number of recognized cases of typhoid fever in these 19 regiments—viz., 1,951—we find that 174, or 8·9 per cent., were preceded by diarrhœa, while 1,777, or 91·9 per cent., had no previous diarrhœal disturbance.

'"We therefore conclude that many of these supposed diarrhœas were really manifestations of infection by the typhoid bacillus, since we cannot otherwise account for the protective influence here so strikingly manifested.

'"We believe that the facts which we have here gathered point irresistibly to the conclusion that at Alger Camp, Va., to addition to the occurrence of a large number of recognized cases of typhoid fever of average duration and

severity, there were still a larger number of milder infections appearing as simple diarrhœas or as fevers of short duration. We shall have occasion to draw the same conclusion from our study of typhoid fever in the other army corps."

'It is not necessary to dwell on the importance of these observations. They plainly indicate that the attacks of diarrhœa conferred a certain amount of immunity from typhoid, and that a considerable proportion of the cases of diarrhœa were in reality cases of abortive or ambulant typhoid. There can be no doubt that these cases of typhoidal diarrhœa play an important part in ordinary civil life, and still more in camp life, in diffusing the infection of typhoid fever.'*

As in the case of diarrhœa, every febrile attack is suspicious. There is an excellent article by Lieutenant-Colonel J. J. Gerrard in the *Journal of the R.A.M.C.* for October, 1909, which bears on this point. Colonel Gerrard's article concludes as follows:

'My only point is to reiterate my belief as to the nature of these fevers. All their signs and symptoms point to their belonging to the enteric group, but to waive them aside as being merely "atypical enterics" seems to me to be only begging the question. Paratyphoid is also an "atypical enteric" in which a particular modification of the enteric bacillus has been isolated. These other fevers differ as little or as much from paratyphoid and from one another as paratyphoid does from enteric, so that there is nothing inherently improbable in their casual organisms being still further modifications of that bacillus. No doubt all attempts at causing the *B. coli* to develop into the *B. typhosus* have so far failed, but I cannot imagine any bacteriologist admitting that he has reached finality. I, of course, am only looking at the question from its clinical side, but to me these fevers seem to form an ascending scale of gradually increasing severity, culminating in enteric fever; and, however heterodox the

* 'Study of Typhoid Fever Epidemics in the United States Volunteer Encampments in 1898,' by Christopher Childs, M.A., M.D., D.P.H.

opinion may be, I believe that they represent stages in the development *de novo* of enteric fever.'*

Although I cannot prove a pathological connection with the morbid conditions now in question, I may state that I have seen both pneumonia and bronchitis occur in a fatal form during the height of an enteric outbreak on the Nile, and this at a time when, according to then existing ideas, prevailing climatic conditions must have rendered such occurrences impossible. Lastly, while admitting the existence of renal or appendicular mischief from the cause in question, the detailed discussion of either is, it must be admitted, outside present purposes.

In dealing with suspicious cases, there is one effectual course—viz., instant removal from effective troops—and for this purpose control of transport by the medical department is absolutely essential (see 'Limitation of Communicable Diseases in War'; also 'Sick Transport').

The question of carriers has occupied a relatively large share of attention during the past few years, both in the service and in civil life. One of the most classical cases on record is that of the Strasburg bakeress, who, being presumably a person of exceedingly uncleanly habits, succeeded in conveying the disease to the whole of the working staff, nine in number, and to a fair proportion of her customers. She had apparently been a carrier for twenty-four years. The question, important enough at any time, is particularly so under war conditions. When men are huddled together in the unwholesome proximity associated with the bell-tent; when water for washing purposes is impossible to obtain; when the same clothes are worn indefinitely, until shirts actually rot under the action of decomposing sweat; when the calls of Nature are obeyed 'everywhere and anywhere'; when food is prepared, and consumed, by men whose hands are soiled with dust, grease, mud, and filth unnameable; and when, to crown all, we know that infective germs in countless numbers are disseminated from the

* 'Further Notes on Fever in Malta,' by Lieutenant-Colonel J. J. Gerrard, R.A.M.C. (*Journal of the R.A.M.C.*, October 19, 1909).

bladder and bowels of the undetected 'carrier,' we can give some idea of the effect produced by this walking agent of infection. During peace the danger can to some extent be grappled with. As an instance of the steps taken, the following extract from a minute of a meeting in October, 1907, of the Standing Committee on Enteric Fever in India is full of interest:

'The Standing Committee on Enteric Fever met in October. The following resolutions, among others, were passed:

'"It has been proved that a proportion of those who have suffered from enteric fever, either in a form recognized as such or so slightly as to escape recognition, and of those who have been in close contact with them, harbour and excrete typhoid bacilli for considerable periods while showing no symptoms of illness. The handling of food by such persons is a great source of danger to others, and outbreaks of the disease have been definitely traced to this source. It is, therefore, strongly recommended that all men, British and native, whom it is proposed to employ in connection with food intended for British troops, in kitchens, officers' and non-commissioned officers' messes, regimental and other institutes, Government and regimental dairies, bakeries, mineral water factories, etc., should be first medically examined to detect and prevent the employment of any who may be harbouring the infection of enteric fever.

'"No man who has recently suffered from enteric fever should be so employed until it has been placed beyond all doubt, by repeated bacteriological examinations, that he no longer harbours the *B. typhosus*. In cases where means for carrying out these examinations are not available, such men must not be employed. Excepting those who have recently suffered from enteric fever or have been inoculated, the Widal test should, whenever possible, be applied, and all whose blood gives a positive reaction should be considered unfit for such employment. All men employed in these occupations should be inspected from time to time by a medical officer for the same purpose.

'"As a considerable proportion of convalescents from

enteric fever harbour and excrete typhoid bacilli, sometimes for long periods, they are a source of danger to troops. It is therefore strongly recommended that accommodation should be provided in the hills for isolating convalescents from enteric fever away from other troops. The places selected for this must have at their command bacteriological laboratories where cultivations from the excreta can be made daily to determine when the individuals are free from infection, also efficient means for disinfection." '*

Convalescent depôts have been established for the care and observation of recovered cases not free from the germ. The following extract from an article by Lieutenant-Colonel A. R. Aldridge on the 'Prevention of Enteric Fever in India' gives an idea of the excellent work that is being done in this direction :

'With a view to isolating convalescents more completely than can be done in most stations, and at the same time providing opportunities for detecting "chronic carriers" with as much certainty as possible, convalescents from the 3rd, 5th, 7th, and 8th Divisions were sent to Naini Tal. The depôt is about a mile from the civil station, and no other troops were stationed there. The divisional laboratory is at Naini Tal, and a special officer, Captain D. Harvey, was detailed to carry out the bacteriological work.

'A steam disinfector for clothing and means for boiling all excreta before disposal were provided. The depôt was opened on April 8, and during the remainder of the year 310 convalescents were received—that is, excluding those invalided to England, more than one-third of the convalescents from all India.

'The urine and fæces of each man (unless already found to be a "carrier") were examined for about seven consecutive days, and none were sent back to their stations until at least four months had elapsed since the cessation of fever. It was found that the great majority of convalescents cease to pass bacilli in their urine within a few weeks of convalescence ; only one man was found still passing them by this channel. Of 190 men whose excreta was examined, six

* Army Medical Report for 1907, pp. 104, 105.

were found to be still excreting bacilli (five in the fæces and one in the urine) more than six months after the cessation of the fever—that is, 3·1 per cent. of the convalescents. These men were all invalided to England, and were still excreting the bacilli eighteen, sixteen, twelve, eight, and six months after cessation of fever. During the year 1,472 examinations of fæces and 1,448 of urine were made.

'As regards the effect of this measure on the incidence of enteric fever at the stations from which the convalescents came, it is found that the admissions for enteric fever from all stations which sent convalescents to Naini Tal show a reduction of 9 per cent. on the figures for 1907, while the remaining stations show an increase of 26·6 per cent.'*

The formation of convalescent depôts has everything to recommend it. Attempts have been made to free the chronic 'carrier' from the germ by means of antityphoid vaccine, but the results have not been encouraging. An infected gall-bladder seems to retain the germ indefinitely.

Personally, I hold the belief that no one should be allowed to have the care or preparation of food if his blood reacts, not only to *B. typhosus*, but also to other germs of the same group, as far as the latter are available for the test.

I would, however, make an exception in the case of *B. coli*, as I have satisfied myself that certain strains of this germ can be agglutinated by healthy blood; the same thing has, of course, been noticed by others. It is certain that no man who is *known* to have had enteric fever should ever be employed in the cook-houses, messes, etc.

Although all reasonable care must be taken, caution should not degenerate into panic. Because a man's blood gives a positive reaction, it does not follow that he is a 'carrier'; at the same time, it is safer to regard him as such. It must also be borne in mind that, according to the combined observations of many workers, only about 3 per cent. of convalescents become chronic carriers, and about 80 per cent. of these are women.†

* 'The Prevention of Enteric Fever in India,' by Lieutenant-Colonel A. R. Aldridge, R.A.M.C. (*Journal of the R.A.M.C.*, September, 1909).

† Army Medical Report for 1908, p. 76.

An apparently trivial matter, but one closely connected with infection, is the proper supply of latrine paper. When acting as Sanitary Officer to the northern force during the Southern Command Manœuvres of 1907, this point was brought to my attention in rather a forcible manner. One of the units was not supplied with the commodity in question, and, without going into certain details, it was clear that, apart from possibilities that might sicken even a primeval savage, the actual danger was of a most pressing nature.

As affecting the spread of the disease by personal contact, the question of the early diagnosis is of prime importance.

Unfortunately, the well-known Widal test is not applicable in the initial stages of the disease; besides which drawback, it is not absolutely reliable; it should, when possible, be made to include *B. paratyphosus* as well as *B. typhosus*. Diagnosis by detection of the germ in the blood promises well for the future, but the technique needs simplification. At the International Congress on Hygiene at Berlin, in 1907, Professor A. Chantemesse, of Paris, described a method adopted by himself for early diagnosis, on the lines of the ophthalmic reaction with tuberculin. Great accuracy in dosage is required. The effects of the toxin are manifest in two or three hours, and a positive diagnosis is indicated by redness and injection of the conjunctiva, lasting one or to days, or sometimes longer.

2. *Food.*—Milk is a well-known vehicle of infection, so that lengthy reference to it is not required. It may, however, be stated that, although infective matter commonly gains entrance after milking, it is an open question as to whether milk may or may not contain pathogenic germs of the nature now in question before leaving the cow. Milk for the use of troops should always be boiled.

Other dairy produce has not attracted the same attention, and the researches of Bruck give every ground for a belief that the pathogenic possibilities of butter in this direction have been somewhat overlooked. Bruck made three series of experiments, in the first of which *B. typhosus* were added

to milk, and butter made from the cream. Typhoid bacilli were found in both the butter and the cream. In the second series the apparatus which was used for the manufacture of the butter was rinsed with the water containing typhoid bacilli. The latter were again found in the butter. In the last series of experiments water, in which clothes contaminated with the typhoid excreta had been washed, was used to wash out the vessels and apparatus. The result was the same as that in each of the preceding experiments. Bruck is also of opinion that typhoid bacilli can survive twenty-seven days in butter.*

The sterilization of milk by boiling is, at times, ridiculed, on the ground that it is impossible to boil butter, and that the latter, for aught the consumer knows, may have been made from contaminated milk. This is very true, and to consume only sterilized milk is, on the face of it, an absolute inconsistency. But if butter cannot be boiled, the milk from which it is made can, and when not specially sterilized, should be boiled. The cows in an Indian cantonment, of which I had at one time charge, were insufficient in numbers to furnish the troops with both milk and butter, and, for the latter supply, purchases of milk were made in the bazaar. It was suggested at the time that this milk should be boiled before being put into the separator. A native employed in the dairy stated that it was utterly impossible to do anything of the sort. But an experiment speedily disclosed the fallacy of his assertions, and with the co-operation of the commanding officer the suggestion was readily carried into effect without the least difficulty. In fact, it was stated by some that butter made in this way kept longer and tasted better than that which was previously in use. In the larger Indian dairies special apparatus for sterilization and cooling are provided, and in the Army Medical Report for 1903 it is recommended that butter in India should be made from sterilized milk only.

Symptoms not to be distinguished from those associated

* *Deutsche Mediciner Wochenschrift*, No. 29, p. 40; Report for 1902 of Sanitary Commissioner with the Government of India.

with enteric fever have resulted from meat-poisoning, and the offending germ has been the *B. paratyphosus*-B, or *B. enteritidis* of Gaertner. An interesting outbreak of food-poisoning occurred in Middlesbrough in 1881. The victims were mostly of the poorer class, and the mischief was traced to a consignment of American bacon. The purchasers were people not likely to be particularly careful about cookery, and the bacon was therefore not heated to the degree necessary to kill the germ which caused the outbreak. The germ was found to be a virulent type of *B. coli*, and the predominant lesion produced was pneumonia. The connection is interesting, as it helps to confirm a previous statement concerning the variety of diseases produced by the typho-colon group. The preventive measures against the above class of danger consist in careful food examination and sound cookery. The matter is further considered in the chapter on food.

3. *Flies.*—The effect of flies as the carriers of infection was brought into evidence during the Spanish-American War, and was emphasized by South African experience. In India the connection is a matter of general knowledge, and the table on p. 71 is interesting as showing the seasonal prevalence of flies in its correspondence with enteric fever.

In the *Journal of the R.A.M.C.* for November, 1909, there is a contribution on the subject of fly-borne infection by Major N. Faichnie, R.A.M.C. Major Faichnie contends that the infective matter is contained in the excreta of the flies rather than on the legs, and he brings forward considerable evidence of an interesting nature in support of his theory.*

Probably the fly which most commonly acts as a carrier of infection is the ordinary house-fly, or *Musca domestica;* it is stated to have a strong predilection for laying its eggs in horse-dung. The *Musca stabulans*, or stable-fly, does not appear to be as important as the first named. The *Lucilia Cæsar* is the bottle germ abomination that was probably

* 'Fly-borne Enteric Fever,' by Major N. Faichnie, R.A.M.C. (*Journal of the R.A.M.C.*, November, 1909).

Stations.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Peshawar	2·0	0·2	0·4	0·6	3·8*	11·2*	10·2	1·6	2·0	2·0	2·8	1·2
Nowshera	—	—*	—*	0·2	0·6	0·6	1·2	0·2	0·4	0·2	0·2	0·2
Rawal Pindi	3·2	1·6	1·6	4·6*	7·8*	10·0	4·4	3·2	3·6	3·4*	4·8	11·4
Lahore Cantonment ...	2·0	—	—*	1·4*	2·4	2·6	1·4	1·2*	1·0	0·4	1·0	1·4
Ferozepore	0·8	0·6	0·4	2·6	3·6	0·8*	0·6*	0·6*	0·2	0·6	0·2	1·4
Multan	0·2	—	—	2·6*	1·4	0·6	0·2	0·2	—	0·4	—	0·2
Ambala	5·8	3·2	6·8	5·4*	7·6*	3·0	1·6	1·0	1·0	2·2	9·4	11·4
Dagshai	—	—	—	0·8	0·6*	1·6*	1·2*	0·4*	—	—	0·2	0·2
Quetta	0·8	0·2	0·6	1·2	1·0	4·8	7·2*	6·8*	11·0*	5·0	11·4	2·0
Karachi	0·6	0·8	0·4	0·8*	0·6*	0·4*	0·2	0·2	0·2*	—	0·6	1·2
Mhow	5·2	3·2	8·2	10·0*	7·0*	2·4	6·8	3·8*	2·6*	2·2	1·4	1·6
Nasirabad	1·2	0·6	8·8	4·6	1·8	0·2	—*	3·4*	2·0	2·4	1·6	0·4
Jhansi	4·4*	3·6*	4·4*	4·2	1·4	—	0·6	4·2	0·8	3·0	1·8*	3·2
Colaba	0·2	0·6	0·4	0·4	0·4*	—	—	0·2	0·6	0·2	0·2	0·2
Kirkee	0·4	0·6	0·6	1·0	1·2	0·6	2·6*	7·6*	5·2	2·6	0·8	0·4
Kamptee	—	0·4	—	1·6	1·2	0·8*	0·6*	1·4*	2·0	1·8	0·2	—
Jubbulpore	0·2	0·6	2·4	3·6	3·0*	1·4*	3·4*	3·8	2·6	0·4	0·2	1·2
Meerut	2·8	2·8	2·6*	9·2*	12·0	7·0*	2·0	7·4	2·6	5·0	12·6	10·8
Bareilly	2·8	0·4	1·0	2·0	2·2	0·6	0·4	1·0	0·8	0·4*	0·8	1·0
Ranikhet and Chaubuttia	—	0·2	1·4	5·0*	4·8*	4·4*	2·2	3·8	2·0	0·6	0·4	—
Cawnpore	0·6	—	0·8	1·6	1·6	1·0	0·4	0·6	1·0*	1·8	0·6	2·2
Sitapur	3·4	—	1·4	1·0	0·8*	0·8*	0·2	0·2	0·2	—	—	—
Fyzabad	1·4	1·0	0·6	2·4*	4·8*	0·4*	0·6	0·8	0·6	0·8	0·8	0·6
Bangalore	1·6	2·4	4·8	1·8*	4·8*	5·6*	8·6	5·2	3·0	3·4	1·2	1·0
Madras	0·6	0·2	0·6	0·6	0·2	—	0·2*	0·2*	0·4*	0·8	0·8	0·2
Bellary	0·4	1·0	0·2	1·4	0·4	0·6	0·2	0·4	0·4	0·4*	2·0*	0·6
Chakrata	—	—	1·0	2·2*	0·6*	0·8*	1·4	0·8	0·2	0·2	0·2	—

Months of greatest prevalence of flies (from Roberts's 'Enteric Fever in India') marked *.

The figures show the mean admission rates per 1,000 for enteric fever amongst British troops from 1902 to 1906 at stations with an annual average strength of 500 or over. (Army Medical Report, 1907.)

familiar to us all in South Africa, and which seemed equally happy on food or on fæces.

The prevention of flies consists in the removal of all refuse generally, and in the total abolition of the dry-earth latrine system. It is stated that the hatching of flies in stables may be to some extent prevented by immediately breaking up the mucous coating of the freshly-passed excreta and allowing the latter to dry.

In general terms our lines of prevention are indicated by the motto, 'No filth, no flies' (Munson).

4. *Dust.*—Dust, like flies, is well known to carry infection. That this should be the case is only a matter of common sense. It is impossible to lay down rules for the prevention of dust, and the matter must be decided by local exigencies and individual judgment.

5. *Water.*—Only a few years ago water was the general object of suspicion, but with increasing knowledge attention has been drawn to other and even more important channels of danger. Old prejudices die hard, and a statement that the influence of water in the spread of enteric fever has been greatly overrated may seem decidedly heretical. That water may be a potent source of widely-spread mischief is an undisputed fact. Comparatively recent events at Maidstone, Lincoln, and Caterham should convince the most incredulous, and there is here not the least intention to raise a doubt as to the vital importance of a pure supply.

All that is intended to assert is that the connection between the water-supply and enteric fever is not of such an intimate nature as that commonly accepted. Two evils arise from what I believe to be an error—firstly, that other dangers in connection with water are overlooked, and measures of prevention taken, such as the use of chemicals, which affect enteric fever only, and leave other, possibly more pressing, dangers untouched; secondly, that a tendency to concentrate a watchfulness in one direction results in the neglect of steps of prevention which, when taken collectively, are every whit as important as the one now in question, and certainly deserve more attention than such

futilities as the use of alum and permanganate of potash. I may here explain that, although each of the above has a certain value, such value does not lie in the direction of germ destruction (see chapter on Water). If we can only grasp and retain the fact that purification is essential not on the ground of enteric fever only, we shall waste less attention on proposals of doubtful and limited utility.

If water had been the cause in 1900 of the Natal outbreak, the latter would have appeared much sooner than it did, and the same may be said of experiences in the Soudan and Upper Egypt in the eighties. On the latter occasion the Nile was regarded as the origin of all our troubles, while we overlooked the fact that the stream had served both as a supply and a sewer for countless generations before the dawn of history, and in the double capacity must have witnessed the rise and fall of a powerful and populous nation, the existence of which would have been impossible had the source in question possessed the poisonous attributes with which we endowed it. It may be argued that the ancient Egyptians preserved themselves from extinction by a sound system of water purification; if this was actually the case, their scheme must have been of a more intelligent order than the grotesque arrangements we adopted some thousands of years later.

In his second report on research work for the Metropolitan Water Board, Dr. A. C. Houston states that, after investigation covering the twelve months ending July 31, 1908, and comprising the examination of 156 samples and 7,329 microbes contained in the same, he was unable to detect the typhoid bacillus in the water either of the Thames, the Lea, or the New River. Dr. Houston rightly adds that 'it would be altogether presumptuous to infer from these observations that the typhoid bacillus is never present in the raw waters.' In his third report, Dr. Houston sets forth the results of experiments on the longevity of the typhoid bacillus artificially added to the above waters. The conclusion is as follows: Eighteen experiments were carried out on the longevity of the typhoid bacillus in samples of raw Thames, Lea, and

New River waters, 'and the results showed that in practically all the experiments over 99 per cent. of the typhoid bacilli artificially added to the experimental water died within one week. Nevertheless, in the majority of the experiments a very few of the typhoid bacilli remained alive one or two months.' * Major J. C. Morgan and Captain D. Harvey, in the series of experiments elsewhere alluded to, came to the conclusion that their results tend to confirm the already accepted impression that the life of the typhoid bacillus in water is an exceedingly short one.†

In 1903, Professor Jordan Russell and Zeit carried out an exhaustive investigation on the longevity of the typhoid bacillus in the water of lakes and rivers. The conclusions arrived at were as follows: 'That under the conditions of the experiment, which probably closely simulate those in Nature, the vast majority of typhoid bacilli, introduced into the several waters studied, perished within three or four days. It is theoretically possible that specially resisting cells may occur which are able to withstand for a longer period the hostile influences evidently present in water. Our experiments, however, show that if such resistant individuals exist, they must be very few in number, and constitute only a small fraction of the bacilli originally entering the water.'

In the face of these investigations, which corroborate the conclusions drawn from Service conditions, it scarcely seems sound sense to attempt the introduction of certain chemical combinations which have a very doubtful effect on a bacillus unlikely to be present, and which, besides being inconsistent with administration in the field, leave untouched other dangers which common knowledge tells us are associated with an impure supply. Take, for instance, the case of the Tugela. The stream rises in the wild and solitary region of the Mont aux Sources. It flows from the Drakensberg

* Proceedings of the Metropolitan Water Board, July 17, 1908; *British Medical Journal*, July 25, 1908. See also effects of storage in chapter on Water.

† *Journal of the R.A.M.C.*, June 19, 1909, p. 594.

FIG. I.—COURSE OF THE TUGELA AS SEEN FROM SPION KOP, SHOWING THE NATURE OF THE COUNTRY AND IMPROBABILITY OF HUMAN CONTAMINATION.

through the thinly populated region of North-West Natal, and before reaching the district once occupied by our troops, its course scarcely lies within the range of human habitations. Judging, however, by written and spoken utterances, the river must be teeming with intestinal germs, which one of the most skilful and experienced of living bacteriologists was unable to discover in a filthy London stream, in great measure composed of the washings of a squalid suburban population.

FIG. 2.—SOURCE OF THE TUGELA.

6. *Clothes and Bedding.*—Infection from this source is well known, and the case of the South African blankets, which spread disease broadcast, may live some time in the public memory. Disinfection on the lines indicated elsewhere is the proper course (see chapter on Limitation of Communicable Diseases in War, also chapter on Disinfection).

7. *Sewer Air.*—It is believed that the above may be the means of conveying infection. Under bygone conditions such may have been the case, but, with properly constructed

sewers, the risk must be very slight (see chapter on Refuse Disposal).

Lastly, we have to discuss the question of antityphoid inoculation. This matter has already been referred to at some length, but must now receive further consideration. The measure in question is, of course, not connected with any special means of spread; its effect, on the contrary, is of a general nature, and from its far-reaching character promises to do more to check the ravages of disease in war than all our efforts in other directions.

In peace and civilization, we may hope that in course of time sanitary measures will gradually obliterate sickness of the nature of enteric fever, and enormous strides, as we all know, have already been made in this direction. In war, on the other hand, enteric fever, like bullets, must be accepted as incidental to the soldier's lot, but with this difference—viz., we cannot make a man bullet-proof, but to a great extent we can make him enteric-proof.

Without wishing to be pessimistic, common sense and experience alike tell us that, from the very nature of things, we cannot hope to establish a system of field sanitation which will grapple with all the ever-changing contingencies of war; but by means of inoculation we can escape dangers which we cannot remove, and a host of difficulties disappear. To legislate for the sanitation of an army corps in the field means a complicated administration and considerable expense. To inoculate an army corps involves, by comparison, a minimum of administration and a minimum of expense, with, it may be added, a far more practical result.

It must not be inferred that there is any present intention to suggest reliance on inoculation, to the exclusion of all other means of prevention. Any such suggestion would be unjustifiable, and would find no support in facts of common knowledge. What the measure may be expected to do is to effect a partial but valuable repair in an otherwise hopeless breach in our preventive armament during war. It should nevertheless be stated that antityphoid inoculation does not

appear to confer any marked immunity against infection with paratyphoid bacilli.*

The published reports of comparatively recent results of antityphoid inoculation in India are set forth below :

TABLE SHOWING THE RESULTS OF ANTITYPHOID INOCULATION FOR THE PERIOD MARCH 1, 1906, TO FEBRUARY 28, 1907.

Average Number of Men inoculated in India or Abroad.	Average Strength of Men not Inoculated.	Cases of Enteric Fever				Ratio per 1,000 of Strength.			
		Inoculated.		Not Inoculated.		Inoculated.		Not Inoculated.	
		Admissions.	Deaths.	Admissions.	Deaths.	Admissions.	Deaths.	Admissions.	Deaths.
4,157	65,666	36	2	1,021	151	8·7	·48	15·55	2·3

TABLE SHOWING RESULTS OF INOCULATION AT JHANSI, SIALKOT, AGRA, BANGALORE, LUCKNOW, AHMEDNAGAR, MHOW, AND AMBALA, FROM JANUARY 1 TO JUNE 30, 1907.

	Average Strength.	Number of Cases of Enteric Fever.	Number of Deaths from Enteric Fever.	Admission Rate per 1,000.	Case Mortality Per Cent.
Not inoculated ...	12,188	181	44	14·85	24·30
Once inoculated ...	1,048	6	1	5·72	16·66
Twice inoculated...	1,340	9	2	6·71	22·22

Seventy-one cases of enteric fever occurred in men who had been inoculated. Of these, 19 had been inoculated once only.

The first table on p. 80 shows the periods between inoculation and attack.

* *Journal of the R.A.M.C.*, June, 1908, p. 600.

	One Year.	Two Years.	Three Years.	Four Years.	Five Years.	Total.
Inoculated once only, within	16	3	—	—	—	19
Inoculated twice or more times, last within	52	—	—	—	—	52
Inoculated twice, within	51	—	—	—	—	51

The average duration of fever was, in the uninoculated, 29·49 days; those once inoculated, 24·72 days; twice or more times inoculated, 21·53 days; twice inoculated within one year, 21·66 days.

The following table shows the incidence of complications, and the case mortality :

	Hæmorrhage	Perforation.	Thrombosis.	Case Mortality.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Uninoculated ...	16·20	5·48	4·88	21·34
Once inoculated	10·53	5·26	—	15·79
Twice or more times inoculated	9·61	1·92	—	11·54
Twice inoculated within one year	9·80	1·96	—	11·76

(Army Medical Report for 1907, pp. 103, 104.)

On January 31, 1909, there were present in India 23,996 warrant officers, non-commissioned officers, and men who had been inoculated against enteric fever, and of this number 2,900 had had enteric fever, whether inoculated or not. 'From this it may be assumed the number of inoculated men was approximately one-third of the total, or half as many as the non-inoculated, omitting those protected by a previous attack of enteric fever. There were 825 cases of enteric fever and 164 deaths among non-inoculated men, and 173 cases and 24 deaths among inoculated.'*

The risks in India, like the risks in war, are in great measure unavoidable, and, although the figures in the subjoined table are satisfactory, they indicate that even able and energetic measures have still left a gigantic problem unsolved.

* Army Medical Report, 1908, p. 82.

'*Enteric Fever.* — There was a slight increase in the admission-rate and decrease in the death-rate for enteric fever as compared with the previous year, the latter being the lowest since 1884. The case-mortality was the lowest recorded in recent years, with one exception; this is no doubt chiefly due to improved bacteriological methods of diagnosis, by means of which many slight cases, which previously would have escaped recognition, are now correctly diagnosed.

Years.	Ratio per 1,000.		Ratio per Cent.
	Admissions.	Deaths.	
1899	20·6	5·14	25·0
1900	16·0	4·77	28·8
1901	12·8	3·32	26·0
1902	16·7	4·29	25·7
1903	19·6	4·18	21·4
1904	19·7	3·76	19·1
1905	16·1	3·00	18·6
1906	15·6	3·19	20·5
1907	13·1	2·77	21·1
1908	14·6	2·74	18·8

(Army Medical Report for 1908, p. 75.)'

In our other foreign possessions or Protectorates the problem of stamping out disease by means of sanitary measures is simple enough as compared with the corresponding problem that confronts us in our Eastern Empire.

In Egypt, for instance, where the possibility of existence is dependent on a single stream, the natives, as a whole, must necessarily be brought more immediately into contact with civilization than in a country not only many more times its size, but also one whose face is covered with races differing, in many instances, almost as widely one from the other as they collectively differ from the races of the West. Time may Europeanize the whole of the Indian Peninsula, but there is no prospect that the present generation of Englishmen will see any appreciable change in habits and

customs the origin of which is lost in the obscurity of countless centuries.

It is regrettable that a primitive mode of life commonly entails an almost complete disregard for ordinary acts of cleanliness and a striking indifference to the most suitable locality for compliance with certain natural wants. In a few words, wherever the lower-class population congregate, there will pollution of soil, water, and surroundings as a whole most certainly occur.

Personal cleanliness is commonly absent, and it follows that members of the above class are often walking disseminators of the most repulsive form of filth. The influence of this state of things must naturally have a widespread effect, and it is no distortion of facts to state that the European in India is constantly exposed to the risk of swallowing excremental refuse conveyed by dust, flies, water, or food, and which, clinging to the clothing and persons of his immediate attendants, is transferred from fœtid fingers to all kinds of articles of intimate use.

It speaks well for the care and enforced cleanliness which are maintained in military institutions for the preparation of food that the sickness of the British troops stands at its present comparatively low figure. As the army in India cannot possibly be self-containing, the soldier is always liable to dangers which there is no immediate prospect of eliminating. In fact, to deal effectually with the origin and spread of enteric fever would involve the obliteration of caste, the prohibition of certain marriage customs and religious rites, the education of countless numbers, and an expenditure that would go some way towards crippling the resources of the Empire.

In many parts of the world where the soldier is called upon to serve, compulsory inoculation may be needless, and therefore undesirable ; but India stands alone in the possession of appalling possibilities in the production of disease, and it is there that Wright's conception should be followed by the widest results — results which must have a vital connection with the maintenance of our national interests.

CHAPTER IV

DYSENTERY AND DIARRHŒA

DYSENTERY

RESEARCHES associated, mainly, with the names of Shiga of Tokio and Flexner of Philadelphia have placed our knowledge of the ultimate causes of the assemblage of clinical manifestations known as dysentery on a fairly satisfactory foundation.

The disease exists under two distinct forms. Firstly, amœbic dysentery: this form is caused by the *Entamœba histolytica;* it is common in the East, is often followed by a single liver abscess, and is amenable to treatment by ipecacuanha. Strictly speaking, the *Entamœba histolytica,* belonging as it does to the Protozoa, should be classed among animal parasites. It consists of a protoplasmic mass of about 30 μ in diameter, and showing slow amœboid movements. A nucleus is present, but stains with difficulty. It is highly important to remember that the organism forms resistant spores, and it is by these spores that infection is believed to spread (Hewlett).

Secondly, bacillary dysentery. This is due to a group of organisms—a fact which renders its successful treatment a matter of great difficulty. It is a usual accompaniment of certain conditions common in war, and is apt to assume epidemic proportions; and it is likewise the form with which we are now principally concerned. It is a most suggestive fact that the causative organisms bear a marked resemblance to the *Bacillus coli,* and that the disease is apt to occur

among insanes. The vital powers of resistance among patients of the above class is lowered, and it has been suggested that normal intestinal germs become pathogenic when the functions of the body are disordered in the direction named. The possibility of this suggestion being correct is full of interest in its connection with the mutability of bacteria as affecting the health of troops on service.

The following extract of a report on an outbreak in the 98th Regiment at Lyons in 1906 is certainly suggestive of a connection between dysentery and what, in default of precise knowledge, may be called simple diarrhœa :

'L'épidémie de 1906 avait persisté par des cas isolés jusqu'à la fin de décembre. Elle se continua certainement jusqu'en juillet par une série presque ininterrompue de diarrhées suspectes, expressions attenuées de la maladie. Cette opinion fut corroborée par le sero-diagnostic, positif dans quelques-unes de ces diarrhées. Au milieu de cette série s'intercalèrent quelques dysentéries confirmées. Dès l'apparition des fortes chaleurs, diarrhées et dysentéries augmentèrent de fréquence. Le départ pour le camp de la Valbonne à la fin de juillet fit disparaître la dysentérie confirmée, mais les diarrhées suspectes avec épreintes sans selles caractéristiques persistèrent, toujours nombreuses. Dès le retour à Lyon, la dysentérie classique fit de nouveau son apparition et fournit un groupement de quatres cas, toujours accompagnés de leur cortège de diarrhées certainement specifiques. . .'*

Ruffer and Wilmore, who have carried out extensive investigations among the Mohammedan pilgrims landing at El Tor, classify the causative agents as follows :

'GROUP A.—AMŒBIC DYSENTERY.

'(*a*) Cases in which the *Amœba histolytica* is found in the stools, and in which all the characteristic clinical symptoms and pathological changes of amœbic dysentery are present. This is a very common form.

'(*b*) Cases in which the *Amœba hystolytica* is present, and in which the *Bacillus dysenteriæ* El Tor (No. 1) is also found.

* Statistique Médicale de l'Armée, 1907, p. 146.

'GROUP B.—BACILLARY DYSENTERIES.

'(*a*) Cases in which the Shiga-Kruse bacillus is found in the stool. This is a comparatively rare form at El Tor.

'(*b*) Cases in which the *Bacillus pseudo-dysentericus* D (Kruse) is found.

'(*c*) Cases in which the *Bacillus dysentericus* (Flexner) is present. We have so far only come across one case.

'(*d*) Cases in which the *Bacillus dysentericus* El Tor (No. 1) is found.

'(*e*) Cases in which other micro-organisms resembling those above mentioned, but not identical with them, are found. We shall not discuss them in this paper, but we may mention that there are at least two varieties of these micro-organisms.'*

The toxin formed by the germs is extracellular, and in this it must be admitted that it differs from the typhoid bacillus, the *Bacillus enteritidis*, and the *Bacillus coli*, in which the poison is intracellular. The serum of horses immunized with the toxin on the lines indicated in connection with diphtheria has been used with success. Immunization of horses has also been carried out by means of dead, and later by living, cultures; unfortunately, for reasons already stated, there is much uncertainty as to whether the serum used is appropriate for the particular microbe to be dealt with, and as several hours are required for the establishment of a bacteriological diagnosis, much valuable time may be lost before the correct treatment can be determined.

To overcome the above difficulty, Shiga has employed a polyvalent serum—in other words, a serum applicable to more than one kind of germ—and his success seems to have been considerable. Cultures killed by heat have been used for prophylactic purposes. Work in this direction is associated with the name of Castellani, who, by his investigations, has thrown much light on the etiology of the disease. Anti-

* 'The Etiology of Dysentery,' by Marc Armand Ruffer, C.M.G., M.D., and J. Graham Wilmore, M.R.C.S., *British Medical Journal* September 25, 1909.

dysenteric serum has been used with success in the French army. The following are the conclusions arrived at as a result of its use during an epidemic at Châlons in 1907:

'Tout d'abord, 12 à 18 heures après l'injection, c'est une diminution notable des coliques. Au bout de 18 à 24 heures, quelquefois après 36 heures seulement, les selles se modifient et deviennent jaunâtres. Le sang disparaît d'abord, puis les glaires. Le nombre des selles diminue aussi beaucomp. Cependant, chez la plupart des malades, elles sont restées assez longtemps diarrhéïques (3 à 4 jours après les injections). La convalescence s'établit plus rapidement que chez les malades qui n'avaient pas été traités par le sérum, et l'alimentation peut être donnée avec une progression plus rapide.'*

The fact that dysentery is a communicable disease must never be lost sight of; and, furthermore, we have cause to believe that convalescents or persons who have never had the disease may act as carriers of either form. According to Professor V. M. H. Vincent, of the Military Medical School, Val de Grâce, the specific bacilli may persist in the intestine, when all other signs of disease are absent, for a period of about four weeks; and in like manner the *Entamœba histolytica* may persist in apparent health, but for much moer extended periods—in fact, it may do so for a year, or even longer. Professor Vincent recommends lavage of the intestine with about 1 in 100 sodium hypochlorite, with the object of destroying the amœba.†

For the present, whatever further work in this direction may reveal, the fact remains that dysentery, as far as purposes of prevention are concerned, is a name applied to certain clinical conditions which are common in the field and elsewhere. All experience goes to show that the ultimate cause or causes of dysentery may be found in organically polluted soil or water, or come into being within the body as the result of a disordered condition of the alimentary tract.

The first named of these causes is probably the one which

* Statistique Médicale de l'Armée, 1907, p. 145.

† *Archives de Médicine et de Pharmacie Militaire,* November, 1909.

has the most direct influence on the health of troops on service. During the closing part of 1885, and practically the whole of 1886, dysentery in Egypt was prevalent at the stations occupied by the troops comprising the Soudan Frontier Field Force. As far as general well-being in the way of surroundings was concerned, this period was a distinct advance on 1884 and about the first nine or ten months of 1885. At some stations, mud huts had replaced tents, latrine buckets had replaced trenches, and comforts of a fairly extensive variety were readily obtained from Cairo and Alexandria. Water received a degree of attention which was previously impossible, boiling being extensively carried out, and, speaking generally, sanitation had distinctly improved. Hospitals also, which had formerly been non-dieted, now received a due supply of medical comforts and the usual appliances for the sick, so that, looking at the matter as a whole, a higher standard of health than that noted in the previous year might have been reasonably expected. As a matter of fact, the health of the force underwent a serious deterioration, as shown by the following figures from the Army Medical Report bearing reference to the periods in question (see also Enteric Fever):

From March 18, 1884, to July 31, 1885, the admission-rate for dysentery was 85·6 per 1,000 of the force. 'Towards the end of the campaign a too free indulgence in tinned provisions by the men retiring down the river was a fertile source of bowel affections.'*

On July 31, 1885, the Nile Expeditionary Force became the Frontier Field Force, and the troops, after this date, remained comparatively stationary. The admission-rates for dysentery of the Frontier Field Force per 1,000 were as follows: August 1, 1885, to November 26, 1885, 87·0; November 27, 1885, to January 22, 1886, 138·5; January 22, 1886, to December 31, 1886, 141·3. In 1887, when the average annual strength was 445 instead of 3,503, as in the preceding year, and when polluting agencies would naturally be lessened, the admission-rate for dysentery fell to 96·6 per 1,000.†

* Army Medical Report, 1884, Appendix I. † *Ibid.* for above years.

These figures are most significant. During the more active period of the operations, when hardships and discomfort were the daily lot of all, when water was largely consumed direct from the Nile, without any effort at purification, and when sanitation in general could not, in the nature of things, receive anything approaching minute attention, the sick returns from dysentery were approximately one-half of what they were at a later date when, as already stated, the troops were enjoying comforts which were previously unknown. The explanation may be found in the following facts : The Frontier Field Force, during the later months of 1885 and the early part of 1886, can, for purposes of comparison, be divided into two distinct parts : first, the troops at Wady Halfa, and to the north of that station—that is to say, those at Korosko and Assouan ; second, those south of Wady Halfa, the latter force being in immediate touch at various points with the enemy. A personal experience may possibly give some idea of the conditions which surrounded the units of the more active section of the army. At different points of the line, between Halfa and Railhead, small detachments were posted to guard our communications south of the Second Cataract. During the latter part of 1885 I was for several weeks in charge of one of those posts. The location was on the river bank, and almost entirely enclosed by volcanic hills in the immediate proximity of the camp. The soil was arid, and vegetation, except for a few palm-trees, was entirely absent. The heat by day was intense, and the nights bitterly cold. For several days after our arrival we had nothing to complain of in the way of food, but when our supplies were exhausted there was considerable difficulty in getting them replaced. As time went on, however, our attention was absorbed by matters altogether unconnected with cookery. The position was one of some anxiety, and comfort and sanitation were alike neglected. The water was drunk unboiled and unfiltered, the violent changes of temperature were rendered particularly trying by the absence of shelter at night, protection from either heat or cold was of the

scantiest nature, and creature comforts in general were conspicuous by their absence. In spite of these disadvantages, the general health was excellent. There was one case of dysentery, which could not possibly have been caused by any local insanitary condition, or other cases would, in all reasonable likelihood, have followed it. Personally, I believe it was due to cold and improper food—in fact, that the *materies morbi* was generated within the body in a manner previously suggested. I should explain that the period referred to was one of about six weeks, and that the average strength was approximately 300.

Although it is illogical to generalize from a single instance, there is good reason to believe that the above is a fair example of the condition of the troops stationed south of Halfa. The period embraces the later months of 1885, and although there was no doubt that early in 1886 many of the advanced posts were hot-beds of sickness, the beginning of their occupation was marked by a standard of health unknown among the troops holding the stations to the north of the Second Cataract. The great point of difference, as affecting sanitation, lay in the fact that one section of the force was, for the most part, in occupation of ground that had not been previously camped on, while the other section was holding posts which had been continuously occupied for the best part of two years. Unless refuse is regularly removed in a manner which is only likely to be possible in peace, every camp, no matter how well supervised, must inevitably have its soil sooner or later thoroughly saturated with organic filth. Whatever the living cause of dysentery may be makes no difference to the main practical fact—viz., that its existence and spread are connected with the presence of intestinal refuse, and this refuse in camps where latrine trenches are in use, or when the contents of latrines cannot be conveyed for disposal to a suitable distance, must infallibly be present. During 1884 and the earlier part of 1885 the troops of the Nile Expedition were, in virtue of comparatively frequent change of position, free from the dangers which arise from a prolonged occupation, under conditions of service, of any

single locality. It is true that they suffered from dysentery, but the explanation of the circumstances is well set forth in the extract quoted above from the report of the expedition, and there is little doubt, judging by experience, that the specific cause of dysentery is quite capable of originating in the intestinal tract.

In the Natal Campaign of 1899-1900 it was a matter of common observation that the old camps, such as those at Chieveley, Surprise Hill, and Hyde's Farm, where the soil was soaked with filth, were prolific sources of dysentery, and it is clear that the cause of the malady was not inherent in the localities, as otherwise the local inhabitants would have rapidly died out under its influence. Dr. Hill, Medical Officer of Health for the Colony, also informs me that in Natal dysentery 'is certainly not prevalent outside the mining areas.'

It is a remarkable circumstance that, as a rule, in South African camps the appearance of dysentery was preceded by that of enteric fever, but although evacuation of the locality rapidly rendered its occupation by new-comers safe as far as the latter disease was concerned, dysentery, on the other hand, remained, so to speak, fixed in the spot for an indefinite period. At Surprise Hill and Glencoe, in the spring of 1900, the unit to which I was attached was attacked by dysentery immediately after its arrival; these camps had been but a short time previously the site of Boer laagers, and although the enemy had suffered from both diseases, dysentery appeared to be the only one which had maintained its vitality in the soil, after the organic pabulum caused by human habitation had been withdrawn.

These remarks, it may be stated, are only intended to embody a suggested explanation of the fact, which agrees with old-time experience, that dysentery hangs about certain localities with amazing tenacity. Those officers of the R.A.M.C. who had the privilege, while at Netley, of attending the lectures of the late Surgeon-General Maclean, I.M.S., are not likely to forget his graphic description of 'the old infantry barracks at Secunderabad, in the Deccan, of dysenteric notoriety.' Trousseau, also, in his Clinical Lectures, gives a striking instance of this peculiarity in

the distribution of dysentery. The passage, from its great interest, is well worth quoting at length : 'La ville de Tours renferme deux casernes placées à égale distance des deux rivières qui traversent la ville, l'une dans le faubourg est, l'autre dans le faubourg ouest. Les mêmes conditions hygiéniques sont adoptées pour l'une comme pour l'autre ; dans l'une et dans l'autre le régime des soldats est identiquement semblable. Cependant à l'époque où je faisais mes études à Tours, pendant les vingt années qui avaient précedé et les dix années qui ont suivi, ce fut toujours le quartier de cavalerie qui fut le premier le foyer du mal. Les quelques soldats de l'infanterie qui, au début, étaient atteints de dysenterie l'avaient contractée dans nos salles de l'hôpital, où ils étaient entrés pour d'autres affections, et l'épidémie n'envahissaient que plus tard le quartier où leurs régiments étaient casernés.'*

Besides soil pollution, errors in diet and many forms of intestinal disturbance, may result in dysentery. Sometimes no cause can be traced. One of the worst cases I ever saw, in which death supervened a few hours after attack, occurred in Barbadoes, in the person of a soldier of the 1st Battalion West Riding Regiment, at a time when, with this exception, the unit was absolutely free from the disease. Nor could the occurrence be attributed to any local condition.

The disease is well known to break out under the influence of chill and exposure, and although it is doubtless more prevalent in hot weather, it is an error to imagine that its presence is inconsistent even with intense cold. Zimmermann records cases appearing at Zurich in January, and amongst the worst cases I have ever seen on service were those which occurred at Glencoe, in the Biggarsberg, in May, 1900. The cold was very severe, but it had no effect in lessening the amount of sickness. It is reasonable to assume that cold produces its effects by bringing about a congested condition of the alimentary tract, and thus altering the vital processes of secretion, etc.—changes which result in the acquisition of pathogenic powers by previously innocent germs. Errors

* 'Clinique Médicale de l'Hôtel Dieu de Paris,' par A. Trousseau. G. B. Baillière et Fils, Paris.

in diet I have already mentioned as a cause of the disease, and I recollect the case of an officer, previously in the very best of health, who consoled himself for past abstinence, during the relief operations, by a meal of magnificent proportions, in Ladysmith, as soon as the necessary supplies were available. Within twenty-four hours he was seized with an attack of dysentery, which came within an appreciable distance of costing him his life. As evidence of the cause of the attack, it is important to observe that he was the only officer of his unit affected, and that he alone of his unit had freely indulged in the pleasures of the table, on this occasion. This example may seem trivial, but it has been introduced as an illustration of what frequently occurs when men who have been subjected to considerable hardships find themselves free to make use of the resources of civilization.

To put the matter shortly, it seems likely that two of the most frequent causes of dysentery, from the practical point of view, are chill and improper food. The lesson is obvious. Daily, or even oftener, the food and cooking arrangements of men on service should be inspected by a medical officer. No detail is too paltry for his attention. The possession of flannel shirts and cholera belts by every officer and man should also be insured. Some officers look upon the use of the cholera belt as a form of 'coddling,' and therefore to be despised, but a common-sense explanation will insure help in this, as in most other directions. Men attacked should be removed from camp, if possible, and in the meantime rigorous measures of disinfection should be carried out. What these measures will actually comprise must depend on circumstances.

Satisfactory refuse disposal, satisfactory food, and satisfactory clothing, are not always obtainable, but they are essential in the prevention of one of the worst scourges of an army, and no pains are too great to secure them.

It should be added that Dopter recently claims to have prepared a vaccine which secures immunity for at least four and a half months, and is unattended by a negative phase; the vaccine consists of an emulsion of killed Shiga's bacilli mixed with antidysenteric serum.*

* *Annals of the Pasteur Institute*, September 27, 1909.

DIARRHŒA.

As the many causes of diarrhœa in the army are, in a general sense, the same as those which occur elsewhere, there is no special reason for entering on a detailed account of the etiological factors of the disease, except in so far as they are dependent on conditions peculiar to military service. Food, water, chill, certain specific causes, are agencies alike common to the circumstances of war and peace, and it would serve no useful purpose to discuss these matters seriatim, as the elimination of all such factors is comprised in attention to sanitary rules which have been already stated, or which are matters of common knowledge. There is, nevertheless, one form of diarrhœa that demands the particular attention of the medical officer; it is that—well known to all who have a knowledge of field service—which constantly tends to break out as an epidemic in old-standing camps or bivouacs, or, in fact, anywhere if soil has undergone serious pullution.

Whether it is due to one or more organisms, and also what the nature of such organism or organisms may be, is a question to which, at present, science can give no completely satisfactory answer. The practical point to be remembered is that the disease is often the precursor of enteric fever or dysentery, and, as such, is a danger-signal the value of which cannot be overestimated. Mention has elsewhere been made of the fact that there is a tendency for enteric fever to gradually replace the disability formerly known as simple continued fever,* and it seems likely that the same tendency exists in epidemic camp diarrhœa. As illustrating this point, the following extract from the Army Medical Report for 1886 is of particular interest, and it is much to be desired that more information of this kind should be collected. The extract refers to one of the numerous camps established near the banks of the Nile: 'The disease began almost immediately on the occupation of the camp, and ran its course, attacking with greater or lesser severity nearly every occupant, and

* In the nomenclature of diseases the term 'simple continued fever,' has been replaced by 'pyrexia of uncertain origin.'

entirely, or almost entirely, ceased when enteric fever showed itself.' 'The medical officer reports that he considers the dirty condition of the camping-ground to have been the chief exciting cause.'* (See also report by Dr. Childs on enteric fever in United States volunteer camps, 1908.)

Less remarkable, but still noteworthy, as affecting the question of connection between diarrhœa and dysentery, is the fact that the admissions for diarrhœa in the Frontier Field Force between August 1, 1885, and November 26, 1885, show a ratio of 173·1 per 1,000 of the strength, the admissions for dysentery being in the ratio of 87·0 per 1,000 for the same period. Between November 27, 1885, and January 22, 1886, the admissions for diarrhœa fell to 101·1 per 1,000 of the strength, while those for dysentery rose to 138·5 per 1,000 of the strength. Lastly, between January 22, 1886, and December 31, 1886, the admissions for diarrhœa were 68 per 1,000, and those for dysentery 141·3 per 1,000.

Such figures, as they stand, are, of course, far too meagre to form the basis for any absolute opinion. They have only been introduced with the object of drawing attention to what would appear to be a useful field for research. Personally, I cannot recollect ever having seen dysentery break out suddenly except in old camping-grounds, such, for instance, as the sites of the Boer laagers which were occupied after the relief of Ladysmith. During the relief operations, in the many camps which were occupied by the column, diarrhœa invariably, except as stated above, manifested itself, in my experience, before the more serious condition.

The men who are attacked should be isolated, if possible, and the excreta destroyed. The latter measure is of exceptional importance; for although we cannot prove, we may nevertheless accept as a fact, for practical purposes, the spread of epidemic diarrhœa by means of the intestinal dejecta. Men should be directed to report sick immediately they are attacked with diarrhœa. If the first few cases can be seen early and isolated, and vigorous sanitary measures taken, it may be possible to stamp out at once an epidemic which, if left untrammelled, may result in crippling the force

* Army Medical Report for 1886, p. 156.

which it attacks. What exact relationship this form of diarrhœa holds to certain other diseases well known on service must remain uncertain for the present; but for the practical sanitarian both 'simple continued fever'—formerly so called—and the epidemic diarrhœa of camps may safely be regarded as making part of a series of pathological terms of which the highest is either dysentery or enteric fever. There is also a general connection between the severity of the flux and the degree of soil pollution in the locality. At Chieveley in the month of February, 1900, diarrhœa was very prevalent. The ground had been more or less in occupation since the Battle of Colenso, and although refuse had been systematically buried, the soil was saturated with filth—as evidenced by the swarms of flies which were present—and practically devoid of vegetation, and therefore of an important means of natural purification. The same experience, under the same general conditions, was repeated at Hyde's Farm, Surprise Hill, and Glencoe. Many of the cases were of appalling severity. The temperature varied, and some of the worst cases were entirely free from fever. The quantity of liquid matter passed was astounding; occasionally the hepatic secretion appeared to be entirely arrested, and although I never saw jaundice in any of the cases, the discharge often resembled milk in appearance and consistence. Mental depression was usually present to a remarkable degree, and occurred early in the attack. It appeared to be a most unfavourable sign. Personally, I found astringents to be of very little use. Condensed milk, or fresh milk when procurable, a liberal supply of brandy, and strychnine or nux vomica, seemed to be the best treatment. To be of use, the brandy should be given in large doses, and treatment should begin with the very least delay possible. It is important to keep the abdomen absolutely protected from chill, and for this purpose the application of a thick layer of cotton-wool and a bandage is a useful measure. The futility of astringents, the profound depression, and the ready response to stimulation and powerful tonics, suggest that the lesion is due to absorption of toxic products, the latter being the result of the presence of a specific form, or

specific forms, in the intestinal tract. This is only a suggestion, but the probability of its truth is borne out by the epidemic nature of the disease and the frequency with which it arises under conditions already described.

Putting aside pathological surmises, we can at least feel assured of the fact, as proved by prolonged experience, that diarrhœa of the nature indicated will, in all likelihood, break out sooner or later in every camp in which organic refuse cannot be satisfactorily removed. In the summer of 1889 I was in charge of a musketry camp at Kilworth, North Cork. Here all refuse was carefully and regularly carted away by a contractor. The general health could not have been better, and, other things being equal, if the same system could have been employed under the ideally healthy surroundings of veldt life, the result would probably have been equally good. At Tyger Kloof in the Bethlehem district of the Orange River Colony, a locality to which reference has elsewhere been made, the camp, which was that of the 2nd East Yorks Regiment, was of comparatively restricted dimensions; it had been under prolonged occupation, and as convoys halted nightly within its precincts, the refuse to be dealt with presented a formidable problem. Thanks to the officer commanding, no system of sanitation could have been more carefully maintained, refuse being removed with the greatest regularity. The effects of this measure were apparent in the fact that, although neither diarrhœa nor dysentery were altogether absent, our standard of health contrasted most favourably with that of other camps where refuse was buried anywhere or everywhere. It is, of course, unfair to make a definite assertion on the strength of one or more instances, but there is at any rate sufficient evidence to accept the excellence of a system of refuse removal as contrasted with one of local burial.

Finally, let it be added that in every outbreak of diarrhœa a local cause should be sought, and if insanitary conditions are present, measures on the lines stated above, including, if possible, a change of camping-ground, may succeed in averting widespread disaster.

CHAPTER V

MALARIA

THE work of Laveran, Ross, Manson, Stephens, Christophers, James and others, has placed our knowledge of the etiology and general pathology of malaria on a basis of comparative security.

We now know that the disease is caused by the presence of certain of the protozoa—viz., the plasmodia, or amœbulæ, of malaria—in the blood, and that conveyance from man to man is effected by mosquitoes of the genus Anopheles. The parasite exists both in a sexual and in an asexual form, and as the general sequence of events presents fundamental points of difference according to the nature of the form present, it will be necessary to consider each case separately.

In the case of the asexual form, the changes noticed are somewhat as follows: The amœbula, which can be recognized as a pale, irregular mass of protoplasm, varying in certain characteristics according to the type of fever, is found within a fluctuating proportion of the red blood-corpuscles of the affected person, at the beginning of, and shortly before, a paroxysm of fever. There are also commonly present a variable number of melanin granules, which gradually accumulate into more or less centrally-placed masses. The parasite contains a vesicular nucleus and a nucleolus, and the melanin granules are in the surrounding protoplasm. The parasites within the corpuscles divide into a variable number of segments—(1) in the quartan type of fever, in which the patient is free for two days, the number of segments

varies from six to twelve, and the life-cycle occupies about seventy-two hours; (2) in the tertian type, in which the attack occurs every other day, the number of segments varies from twelve to twenty, while the life-cycle occupies about forty-eight hours; (3) in the æstivo-autumnal, malignant, subtertian, or pernicious type, the course of events is irregular. The asexual parasite, as it multiplies by fission, is spoken of generically as a 'schizont,' and the segments, resulting from division of the parasite, as 'spores.' The above types of fever are caused respectively by the *Plasmodium malariæ*, by the *P. vivax*, and by the *Laverania malariæ*.

In the quartan type the parasite nearly fills the whole of the corpuscle, the latter, however, not being much altered. The pigment granules are numerous and coarse, and the division results in the formation of a symmetrical rosette. In the tertian type the corpuscle is markedly enlarged, is pale, and is completely invaded by the parasite; the pigment granules are comparatively fine, and constantly change their positions. In the malignant form the corpuscles often become shrivelled and dark in colour; multiple infection and even destruction may take place without ascertainable infection by the parasite; crescentic bodies appear in the blood, also 'fission' forms, the latter being found in the internal organs.

After completion of segmentation by the parasite, the corpuscle breaks down, and the spores, being free in the blood, attach themselves to other corpuscles, and by developing into mature amœbulæ complete the cycle of asexual change; while infection is caused by the conveyance of the spores from man to man through the agency of mosquitoes.

In the case of the sexual parasite the course of events is rather more complicated. Development is slower than in the case of the 'schizont,' and the segments produced, being possessed of sexual attributes, are styled 'gametocytes,' to distinguish them from the asexual segments, or 'sporocytes.' It is not known what conditions determine whether an amœbula shall produce 'sporocytes' or 'gametocytes.' Fertilization takes place in the middle intestine of mosquitoes

belonging to the genus Anopheles. When blood is withdrawn by the mosquito from its victims, the male gametocytes in the affected blood, after being freed from the corpuscles in which they are confined, develop a varying number of flagellæ, the latter corresponding to the spermatozoa of higher forms; these flagellæ, or 'microgametes,' break away from the main body and make their way through the blood to the female gametocytes, or 'macrogametes,' and union with the latter results in fertilization, the fertilized body constituting a 'zygote.' The 'zygote' develops into a motile body, or 'ookinet,' which makes its way into the outer wall of the stomach, and there becomes encysted.

The next change consists in the division of the substance within the ookinet capsule into from eight to twelve portions which, in their earlier stages of development, are spoken of as 'zygotomeres,' and later, when they become spherical, as 'blastophores.' Each blastophore develops on its surface numerous radially-placed bodies known as 'sporozoits,' until finally the capsule, being full of thousands of 'sporozoits,' ruptures, and the latter are dispersed into the body cavity of the mosquito. The 'sporozoits' make their way throughout the body of the host, and those which reach the salivary glands are discharged, by the proboscis of the mosquito, into the blood of the persons attacked. In the blood the 'sporozoits' attach themselves to the red corpuscles and develop into the mature parasite, and then pass through the intra-corpuscular changes described above.

If some points are still obscure, there is no doubt as to the main principle—viz., protection against mosquitoes of the genus Anopheles—which should govern us in our efforts at prophylaxis. The process of development of the mosquito —that is to say, the laying of the egg, the passage through the larvæ and pupal forms, and the ultimate completion, all take place in water, and these facts are essential guides to action.

The practical application of the principle of protection is, on the other hand, far from certain, and offers, therefore, a fair field for useful discussion. It may be well to pass in review the main proposals which have been set forth with the view of attaining the above object.

1. The Draining of Malarious Regions.

Whether this step is applicable depends on a variety of considerations, topographical, financial, and otherwise; but its value does not admit of the smallest doubt.

In many of our very worst stations drainage is out of the question. At Delhi, where the disease is rife, the River Jumna, in the rainy season, washes the walls of the fort on the east side. As the river recedes literally miles of country

FIG. 3.—EAST WALL OF THE FORT DELHI, SHOWING THE DRY BED OF THE JUMNA.

In the rains the river washes the walls of the fort.

are covered with stagnant pools, in which the larvæ can increase by millions, so that the fort is in the immediate vicinity of a breeding-ground of singularly fertile character. It is only common sense to accept the fact that as long as the course of the Jumna remains unchanged, so long will malaria abound, and so long will minor measures, such as oiling catch-pits, mosquito-curtains, etc., prove unsatisfactory.

The British battalion at Meerut furnishes a detachment

for the Delhi fort, and it was commonly believed at Meerut that the Delhi companies could readily be 'spotted' on parade by their generally cachectic appearance.

It has been pointed out by Lieutenant-Colonel Cunningham, I.M.S., that the excavations carelessly left after engineering operations become, when filled with rain-water, prolific sources of Anopheles larvæ.

It is unfortunately true that the Mian Mir experiment in the direction of drainage was far from a success. The work has been so fully criticized that any prolonged discussion of it is needless. Let it suffice to say that failure in this instance does not in any way detract from the soundness of the principle of which the operations were the practical expression. Failure was clearly due to financial causes, and should not reflect on the skill and energy of the officers concerned. As Professor Ross states : 'Mian Mir must cost the Government alone some thousands of pounds annually, representing the interest of perhaps fifty to a hundred thousand pounds capital, and it is therefore a sum of this magnitude, and not a poor hundred or two, which for economical reasons alone may be spent in banishing the disease there.'

While the admission rate for malaria and simple continued fever in Mian Mir has come down in recent years in general agreement with that for the whole of India, yet, in spite of exceptionally energetic anti-malarial measures, the amount of malaria is still greater than the average for the whole country.'*

Among the most remarkable results achieved by drainage and general sanitation are those connected with the administration of Colonel Gorgas, United States Army, in the canal zone of the Isthmus of Panama. The task to be performed would have been impossible of completion in less able hands, and the issue now stands as a memorial of American enterprise and American enlightenment. The remarks of Professor Ronald Ross on the nature of the work are of particular interest.

'*Panama.*—As is well known, the attempt of the French to cut the canal through the Isthmus was foiled principally

* Army Medical Report for 1908, p. 93.

by yellow fever and malaria, and I was told that their effort had cost quite 50,000 lives. The Americans took possession of the works early in 1904, at a time when the mode of propagation and of prevention of both diseases was well known, and they wisely determined to commence their labours with sanitation. Colonel Gorgas, assisted by a capable and enthusiastic staff, was put in charge, and attacked the work with knowledge and energy. I visited the place at his invitation in the autumn of 1904, and was a witness of the skill shown in his dispositions. The country is one of the worst to deal with which I have ever seen. Hilly, with a great rainfall, a loose, crumbling soil, a luxuriant vegetation, and innumerable small marshes and pools, it was evidently the very stronghold of malaria. Step by step, with the aid of numerous experts and hundreds of workmen, the Americans cleared the forests, drained the pools, and banished the Stegomyia.' 'Put briefly, the results are that in 1906, amongst 5,000 white American employees, the total death-rate was only 7 per mille, and of this, only 3·8 per mille were due to disease. Last April the daily sick-rate of the total force of about 40,000 people was only 17 per mille.' Colonel Gorgas says: "Among 6,000 Americans in the employ of the Commission, including some 1,200 American women and children, the families of these employees, we have but little sickness of any kind, and their general appearance is fully as vigorous and robust as that of the same number of people in the United States.' These published statements are fully borne out by private communications from individuals living there. Colonel Gorgas adds: 'I think the sanitarian can now show that any population coming into the tropics can protect itself against these two diseases (yellow fever and malaria) by measures that are both simple and inexpensive . . . and that, again, the centres of wealth, civilization, and population will be in the tropics, as they were in the dawn of man's history. . . .'

'In this great work of Colonel Gorgas and his colleagues I recognize the attainment of that ideal which was set before me when, ten years ago, I found the zygotes of the parasites

of malaria in mosquitoes. I regret only that the honour of attaining it has not fallen to my countrymen, as might well have been the case. But we must none the less congratulate the Americans on the splendid achievement with which they have signalized their entry into the lists of the colonizing nations of the world.' *

Scarcely less brilliant are the results first obtained in Havana, also due to American initiative. In 1880 there were 335 deaths from malaria, and the annual figures down to 1906 inclusive are as follows:

Years.	Deaths (Malaria).	Years	Deaths (Malaria).	Years.	Deaths (Malaria).
1880	335	1889	228	1898	1907
1881	228	1890	170	1899	909
1882	191	1891	203	1900	344
1883	183	1892	202	1901	151
1884	196	1893	240	1902	77
1885	101	1894	201	1903	51
1886	135	1895	206	1904	44
1887	269	1896	450	1905	32
1888	208	1897	811	1906	26

These figures were furnished to Professor Ross by Dr Charles Finlay, Chief of the Health Department, Cuba. Professor Ross's general conclusions are set forth in the following extract from the address referred to:

'1. For tropical sanitation against both malaria and yellow fever (and probably filariasis) general mosquito reduction is by far the most practical, as it is the most fundamental, method—at least, in thickly populated areas. In support of this proposition, originally advanced by Finlay for yellow fever, and now by myself for malaria, it suffices to quote the greatest living authority on the prevention of both these diseases—Colonel Gorgas—who for more than six years continuously has been waging successful war against them, not on a small but on a large scale, and not in easy but in

* 'Prevention of Malaria in British Possessions, Egypt, and Parts of America,' by Ronald Ross, C.B., F.R.C.S. Eng., D.P.H., F.R.S. International Congress of Hygiene and Demography, Berlin, September, 1907

the most difficult possible conditions. Regarding yellow fever, he says: "When we left Cuba after the disappearance of yellow fever, we were inclined to think that the results had been obtained principally by the destruction of the infected Stegomyia, but further experience at Panama has convinced me that the important element is the destruction of Stegomyia generally. I merely mention this as showing how practical work and experience entirely change well-grounded theories." Regarding malaria, after enumerating the various methods of prevention, he says: "By far the most important of these measures is that of destroying the breeding places, and this is successfully done by surface and subsoil drainage." So many people write on this subject without any real practical experience of it that we shall do well in future if we listen more attentively to such words as these of Colonel Gorgas.

'2. Prophylaxis by quinine, by screens and by segregation, may be attempted, if possible, in addition to the fundamental measure, but, as regards tropical towns, must be looked upon only as adjuvants to it. As a rule, in the tropics general cinchonization is feasible only for officials, troops, and bodies of workmen; and screening and segregation can seldom be used except for public buildings and the houses of Europeans. All should be advocated, but there is a distinct danger of wasting on the subsidiary measures efforts, funds which might be more usefully spent on the fundamental one, a thing which I have frequently observed to happen. For example, cinchonization is being much advocated, and quite rightly so, for the troops in India, but at the same time irrigated fields are often permitted to remain in the close vicinity of barracks.

'Hence, while the number of relapses among the men may be reduced, yet probably just as many as before become infected from the surrounding untreated population, and a false impression of improvement is given. It is constantly forgotten that for the individual quinine is, properly speaking, not a prophylactic at all—it does not exclude infection, but merely extirpates it (in some cases) after it has effected

an entry. It is poor policy to substitute a possible extirpation for a certain exclusion. On the other hand, the subsidiary measures become essential where it is not worth while to attempt mosquito reduction, as in the case of camps and many isolated houses, farms, plantations, etc.

'3. There is no doubt that the mere knowledge of the fact that mosquitoes cause infection is producing a great improvement of the health of educated people in the tropics. This occurs in two ways: first, such people are more careful in the use of nets; and, secondly, medical men, without undertaking formal campaigns, do more than formerly to suppress breeding pools close to houses, barracks, etc. There is thus a kind of unconscious prophylaxis beginning to be adopted everywhere. The following figures, which I have collected from the Indian Sanitary Reports, give some evidence of this:

Admission Rates per 1,000 for Malaria in India.

	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904	1905.
Gaol prisoners ...	292	383	348	350	364	382	375	366	346	336
Native troops ...	292	363	355	277	335	373	286	256	201	180
White troops ...	253	420	427	245	321	300	254	247	177	114

These statistics refer to the prisoners and troops of the whole of India, and are, therefore, very reliable. It will be observed that the admissions among the prisoners have not decreased, owing to the fact that these people, drawn from the lowest class of the population, are constantly being changed in the gaols, so that sanitary improvements, as regards malaria in these buildings, can produce little effect on their fluctuating population. On the other hand, there appears to be a considerable decrease among the troops, all of whom have medical men in charge of them, while the white troops are provided also with mosquito-nets or punkahs. There has been a slight increase in the amount of simple continued fever, diagnosed, but not nearly enough to account for the fall in the malaria rate.

'4. But unconscious prophylaxis of this kind will not do everything, and State intervention is necessary if the fullest results are to be obtained. Here two great mistakes have been made.

'The first mistake is to suppose that we can educate the general public by means of notices and pamphlets to protect themselves against disease—a mistake constantly made by inexperienced sanitarians. We may reach a few educated people in this way, but, as every practical health officer knows, the masses will not trouble to take the advice. It is ridiculous to suppose, for example, that a large native population will use nets, or take quinine, or destroy mosquitoes, simply because the "doctors" advise them to do so. Even among civilized nations hundreds of thousands reject so simple a precaution as vaccination. In other words, from a sanitary point of view, the general public is a child which must have everything done for it.

'The second mistake is to suppose that small local authorities, if left to themselves, will interest themselves greatly in sanitation. A review of the campaigns against malaria which I have discussed will show that all of them are due to the energy and intelligence of single persons. If a locality possesses a governor or a medical man of capacity, the campaign is started, and is continued as long as he remains there; if not, nothing whatever is done. The truth is simply that local officials are, as a rule, unwilling to take the necessary trouble. *Secure of their pay and of their pensions, they easily avoid the obligation by pretending that the work is too difficult or too expensive.* Now, the only way to overcome this inertia is to use official compulsion from the higher authorities. But, strange as it may seem, I have not known a single case in which such action has been taken. The local authorities are allowed to go their own way quite uncontrolled, and are not even compelled to collect statistics. At the same time, nothing is done to encourage sanitary officials to bestir themselves in this line. I have not heard of a single instance in which anyone who has really done good work against malaria has received

official thanks or reward for his pains, while, on the other hand, honours have been given to men who have actually retarded such work. There is often much pretence of action —conferences are held and speeches are made, but the years elapse and—the malaria remains as it was.

'Besides local inertia, there is another reason why local efforts against the disease are so often limited, and that is the fact that medical men in the smaller colonies do not always possess the knowledge of how to use the colonial resources to the best effect. Ill-advised attempts are made, and result only in failure, waste of money, and discouragement of other efforts.'*

2. Kerosine Oil to Collections of Stagnant Water.

This measure should only be resorted to when the collections of water are limited in volume. For instance, a few puddles can be covered over without difficulty; but in dealing with large collections it is not only utterly useless, but is distinctly to be deprecated, as drawing attention from steps of more practical value. The amount of oil required to cover a surface of 10 square feet is enormous—that is to say, if the oil is to be applied in such a manner as to yield anything worth calling a probability that it will remain undisturbed. Thin layers are useless; the oil runs together in large globules, and is disturbed by the least breath of wind. If the oil is poured from a height, it fails hopelessly on its object, as it breaks up and then runs together in the manner just stated: it might as well be poured over the ground, for any good that it is likely to do. Rain scatters the oil, and any bulky object carelessly or mischievously thrown into the water will do the same. I had the opportunity of watching the results of this step when in charge of the fort at Delhi, and I was careful to compare my

* 'Prevention of Malaria in British Possessions, Egypt, and Parts of America,' by Ronald Ross, C.B., F.R.C.S. Eng., D.P.H., F.R.S. International Congress of Hygiene and Demography, Berlin, September, 1907

experiences with those of other officers whose periods of residence in India were longer than my own.

The opinions expressed were unanimously unfavourable. After all, it does not take prolonged experience to see the absurdity, with the reservation stated above, of means which are in general not only useless and wasteful, but, by producing a fallacious appearance of prevention, actually prejudicial to the adoption of radical measures.

3. Mosquito-curtains and Punkahs.

These can only be of partial value, the occasions on which men are open to the attacks of Anopheles being too constant to allow the curtains to have any widely useful result. Mosquito-curtains have very little to recommend them when punkahs are in use. If the fringe of the punkah hangs low enough, and the coolies carry out their work, the mosquito annoyance is scarcely felt. In countries such as the West Indian Islands, where mosquitoes abound, and punkahs—at any rate, as far as my own experience goes—are unknown, the mosquito-net is not only a comfort, but a necessity. In India, the Anopheles is rife during the season when the punkahs are still required. The air-space within the mosquito-net is never of the freshest. The punkah, on the other hand, by keeping the air in constant movement, has a most cooling and refreshing effect. During the hottest months of the year a mosquito-net is unbearable. As Anopheles is still present after the end of the hot weather, the mosquito-net becomes useful when the punkah has been put aside. It would be a fair way of summing up the matter to state in general terms that the mosquito-net should be looked upon as a protection against all mosquitoes during the hours of sleep, but not as an efficient protection against malaria.

4. Wire-gauze Doors and Windows.

These are, doubtless, a great comfort, but they are far from a perfect protection. It is impossible to keep them constantly closed; they interfere with the use of 'tatties,' and the protection that they afford only extends to the house.

5. Prophylactic Doses of Quinine.

There is sufficient evidence to justify a hopeful attitude concerning the utility of this measure, although there is considerable diversity of opinion relative to details of administration. It is commonly held that a dose of 15 grains of sulphate of quinine taken on two successive days gives good results. A large and rapidly-repeated dose of this sort to a person unaccustomed to the drug is almost sure to be followed by unpleasant symptoms, and, in the case of a soldier, might easily incapacitate for a day, or even for a longer period. I have seen good effects follow the administration of 3 grains daily, taken after sunset, and fasting.

No doubt the best means has yet to be discovered, and it should not be forgotten that men are not all alike, and that the dose should be proportionate to the requirements and general condition of the patient. On one point all medical officers appear to be agreed—viz., that if the quinine is to be of any use at all, it must be given under supervision. It is useless to entrust a non-commissioned officer, no matter how apparently reliable, with quinine tabloids for administration. The soldier is often intensely suspicious as to the disinterested nature of any kind of innovation which affects himself, and when a proposal comprises arrangements which interfere with his comfort and convenience, his resentment is aroused to an extent which prompts him to nullify, by every means in his power, measures which are designed with a view to his benefit. The only feasible plan is to parade the men at the hospital, and have the administration carried out under the direct supervision of a medical officer or, in India, of an assistant surgeon.

The report for 1908 of the commanding officer of the station hospital, Ambala, Lieutenant-Colonel F. H. Treherne, is unfavourable to the measure:

'It is impossible to state to what extent this issue (10 grains on two consecutive days, followed by 5 grains for the next five days) influenced the incidence of the disease. The issue was very thoroughly carried out this year under

the direct supervision of medical officers, and more satisfactory results would have been anticipated.

'The action of quinine in the blood is to inhibit oxygenation, checking the formation of the oxyhæmoglobin, and resulting in the deficient oxygenation of the tissues. Certainly, after the prophylactic issue had been continued some time, a very large number of the men looked extremely anæmic, and it becomes an open question whether this anæmia might not really have been caused by the quinine itself rather than by the malarial toxin, to prevent the formation of which was the object in view.

'The issue was commenced in the first week in August, and in the third week in September the disease was at its height. The rains ceased at the end of August.

'As is usual, the men disliked the quinine parades, and many adopted every means they could to avoid swallowing the dose. Tabloids of quinine were found unsuitable, since many men kept them in their mouths until the parade was dismissed, and then threw them away. Hence quinine in solution was administered, and each man had to shout out his regimental number immediately afterwards to prove that the dose had been swallowed.

'At Multan, a bi-weekly issue of quinine in 10-grain doses in solution was given to the 52nd Battery R.F.A. from August 17, on two successive days, until September 7, when the dose was increased to 15 grains. A bi-weekly issue of 15 grains on two successive days was given to the men of the 2nd North Staffordshire Regiment from September 5 to November 30. The Howitzer Battery R.G.A. received none. Taking the prevalence during the months of September and October, when the strength of the corps underwent little change, the prevalence was somewhat greater in the R.G.A., which had no issue, and was quartered in the defensive post, than in the R.F.A. and the 2nd North Staffordshire Regiment, which had the issue and were quartered in the cantonment proper, but the higher ration of admission in the R.G.A. might be accounted for by the higher percentage of Anopheles there. The R.F.A., which

received an issue a fortnight before the 2nd North Staffordshire Regiment, had a higher ratio than it.

'When the issue was stopped, no apparent increase of admissions was noted. Therefore it is difficult to say if any benefit was derived from the issue. There is, however, no doubt that the issue as given proved a very inefficient prophylactic, and it is easy to understand how a considerable number of medical officers do not believe in its use.'*

6. Removal of Troops from Malarious Regions.

It is quite evident that this measure is not always applicable, but when consistent with military exigencies it is one of the best and most common-sense means of prevention we possess.

'It has, in years past, been the practice to bring troops back from the hill stations early in October—that is, almost in the middle of the malarial season. A trial was made in 1907 of keeping them in the hills until the middle of November in the 1st Division, and until the end of October in the 2nd Division, and the results have been very satisfactory. The gain in efficiency, which this means, seems well worth the cost of a few weeks lost for training.'†

7. Destruction of Mosquito Larvæ by Fish.

Attempts to destroy the mosquito larvæ by means of fish have not been very encouraging, but latterly hopes have been kindled that by means of the *Girardinus pœciloides*, a small fish found in the West Indies, and commonly known as 'millions,' good results might be obtained. These fish are stated to be fairly hardy, and to be almost omnivorous feeders. As seen in the water, they are rather suggestive of minnows.

During a recent voyage to the Cape I had charge of a consignment of the above; they were intended for use in Mauritius, but up to the present I am unaware of the result of the experiment. I found that they required a good deal

* Army Medical Report for 1908, p. 91.

† Army Medical Report for 1907, p. 108.

of attention, and that the water had to be changed more frequently than I anticipated from the printed directions with which I had been furnished. I found that the frequent appearance of the fish on the surface was a sign that the water should be changed at once. If this point is not carefully attended to, the fish soon die. Unfortunately, jolting is very inimical to the safety of the fish, so that they are apt to die off rapidly as the result of a railway journey.

It is now realized, if not fully, at any rate partially, that malaria is transmissible from man to man, although, with our present knowledge, the condition cannot be classified, as far as practical measures of prevention are concerned, under the same heading as other communicable diseases. The work of Christophers, Stephens, and James leaves no room for doubt that the Anopheles abounds in native Indian

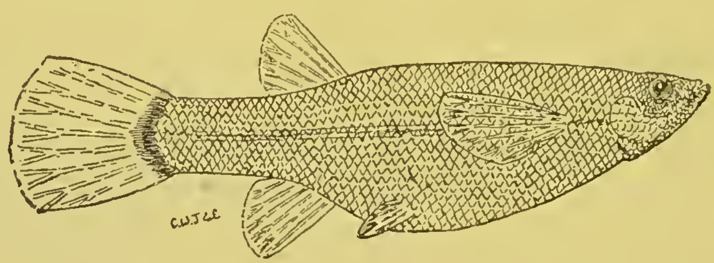


FIG. 4.—GIRARDINUS PŒCILOIDES (DE FILIPPI).
About twice natural size. (Department of Agriculture for the West Indies.)

habitations. They seem to spread from the bazaar as from a centre, and their flight appears to be dictated by a necessity for food. Given a native population, a high percentage of whom is affected with malaria, and given, also, the presence of the Anopheles, we have at once a satisfactory reason for the removal of the troops, as far as possible, from such sources of infection. This measure is an illustration of the principle known as the 'segregation of the European.' At Delhi a large number of native servants live in the fort, and many of these are sufferers of malaria in some form or other, so that, besides the influence of the river, there is a constant supply of malarial matter available for the propagation of the disease. As native children are affected early in their lives, and as treatment is infrequent, they constitute fertile

and constant sources of malarial infection. The infection appears to decrease with age. It is an interesting and important fact that native children may be seriously affected without showing any corresponding signs, and the presence of the disease may consequently easily be overlooked. The danger of infection from children has been well pointed out by Captain S. P. James, I.M.S.* It is among children, therefore, that the prophylactic administration of quinine may be expected to work for special good.

In the Annual Report for 1903 of the Surgeon-General of the United States Army to the Secretary of War there occurs prolonged reference to the work of Lieutenant Charles F. Craig, Assistant Surgeon, United States Army, on the ubject of latent and masked malaria. According to the above, Lieutenant Craig states 'that since special attention has been paid to this matter, he has observed 367 cases of masked or latent malarial infection, about one-fourth of all cases in which the malarial parasite were found. Of the 367 cases, he found some variety of æstivo-autumnal parasite 269 times, the tertian parasite 95 times, and the quartan 3 times. In 282 cases the parasites were few, and in 82 they were numerous.'†

At a meeting of the Académie de Médecine, Paris, held on October 4, 1904, Laveran stated that the persistence of malaria in Madagascar was due to latent infection in young natives, and that their blood, on repeated examinations, was found to be infected with hæmatozoa.‡

These facts are an illustration of the possibility of the spread of the disease from the followers and others who are brought into immediate contact with troops, and who may be affected without giving visible signs of mischief.

In considering any scheme for the prevention of the disease, the fact of there being two essential factors in its

* Scientific Memoirs by Officers of the Medical and Sanitary Departments of the Government of India, 'Malaria in India,' p. 61.

† Annual Report of Surgeon-General United States Army for Fiscal Year ending June, 1903, p. 59.

‡ *British Medical Journal*, October 15, 1904.

propagation should never be lost sight of—firstly, the presence of the parasite ; secondly, the presence of the Anopheles. Without the parasite the Anopheles is no more harmful than any other kind of mosquito. It is, therefore, quite possible to introduce malaria into a locality where it has been previously unknown, provided that the necessary means of transmission are in existence. It is thus clear that if malaria is to be stamped out of any community by means of emigration to a fresh locality, the absence of the Anopheles in the latter must be determined with certainty, and its transmission must be duly guarded against.

In the spring of 1898 the 3rd West India Regiment arrived at St. Helena after a punitive expedition on the West Coast of Africa. It is no exaggeration to say that the battalion was almost crippled with malaria. Although there are in St. Helena a few mosquitoes, the Anopheles is fortunately not amongst them. Not only had the malaria disappeared in about six weeks, but the battalion was in a high state of physical efficiency. I do not think there was anyone in the island who had the least knowledge of the appearance of the Anopheles. For anything that was known to the contrary, this form might easily have been present. It was a fortunate circumstance that it was not so, or a locality where natural beauty is equalled by a perfect climate would have been converted into a hotbed of disease. Relapses, it is true, occurred amongst the men, but a relapse is not the same thing as a reinfection ; the distinction is an important one, as the former has no connection with mosquitoes.

Under ordinary circumstances questions of such magnitude as the removal of troops or the drainage of extensive areas are not left to the decision of any one individual. There are, nevertheless, measures which every medical officer can institute, as a rule, of his own initiative, and notably among them is the systematic administration of quinine, remembering always that to be efficient it must be carried out under intelligent and responsible supervision. The use of kerosine in the usual manner is, as already stated, quite unreliable, except in the case of small collections of water, which may

be just as easily filled in. Although the use of mosquito-curtains should never be omitted, it is a mistake to look on it otherwise than as an auxiliary measure. And, lastly, it must always be borne in mind that the quarters of native followers, syces, and the like are fertile sources of infection, and that the detection and treatment of cases in native children is a valuable means of prophylaxis.

The distance which Anopheles may cover during flight in search of food is a matter concerning which there is considerable discrepancy of opinion amongst those who are best qualified to speak. I have elsewhere referred to a case in which it seems likely that malaria was contracted on board a passenger steamer outward bound for the Cape. The vessel appears to have passed exceptionally close to Cape Verde, and one of the passengers, who had never been exposed to malaria in his life, was seized with a typical attack of the disease shortly after reaching his destination at St. Helena. The patient's son, who was one of the medical officers doing duty in the island at the time, assured me that there was no doubt whatever as to the nature of the illness. Endemic malaria, as already stated, is unknown in St. Helena.

There is good reason to believe that Anopheles larvæ may in India be carried long distances by canal water. Other streams also have the same effect. The possibility of spread of malaria by these means should never be forgotten.

There are many excellent written and pictorial descriptions of the Anopheles and its larvæ. None of these can, of course, equal in value actual experience of the mosquito as the latter occurs in nature. The larvæ can easily be collected by filling a glass bottle, with a wide neck, from an infected source. By fastening a piece of thin muslin over the mouth of the bottle, developed forms can be prevented from escape when they come into being, and the whole process of change carefully watched. The time spent in observation is not thrown away, as, once the general appearance of the larvæ and developed mosquitoes are fairly stamped on the memory, the knowledge gained qualifies the observer to offer advice and to express opinions on matters

the importance of which is sufficiently obvious. Full directions for collection and observation can be found in the 'Causation and Prevention of Malarial Fevers,' by Captain S. P. James, I.M.S.

Without attempting to go into detailed descriptions, it may be noted that there are two useful points to be observed in the detection of the Anopheles. One is that the mosquitoes have been observed to fix on their victim with their bodies at right angles to the point of attack, and the other is the common presence of spots along the anterior edges of the wings. The attitudes are also characteristic, but are not infallible as a means of recognition. 'When an Anopheles is resting on a wall it keeps its proboscis, head, thorax, and abdomen in one line, and the hinder part of its body projects outwards from the wall, so that the insect appears to be standing on the tip of its proboscis. With the culex mosquitoes the body is either kept parallel to the wall or the tail is even nearer to the wall than the front part of the body, so that a culex appears "hunchbacked." There is one very important Anopheles (*A. culifacies*) which, when sitting on a wall, looks exactly like a small brown culex, and keeps its body parallel to the wall, as a culex does' (James).*

A rough but useful means for detecting the larvæ of Anopheles is by observation of the position of the forms in the water. The larvæ are observed to lie horizontally beneath the surface, a fact which is explained by the situation of the breathing apertures, the latter being placed dorsally, and thus brought close to the air.

The question of the breeding-places of the Anopheles larvæ is obviously of great importance, and the following observations are therefore of practical value:

'It is now well known that the Anopheles larvæ may occasionally be found in almost any collection of water, of whatever nature it may be. This fact has an important application when any practical measures at extermination of larvæ are attempted, in that it leads us not to overlook even the

* In nature, *A. Rossii* is stated not to convey malaria, although it has been experimentally infected.

most unlikely places in our search for larvæ; for unless we search systematically every collection of water, temporary or permanent, we may easily allow an important breeding-place to remain when we think all possible breeding-places have been done away with.' *

The connection between malaria and supplies of drinking-water appears to have been slightly overlooked in late years, the attention of observers having been more or less attracted to the study of Anopheles and the most ready means for its destruction. The possibility of the parasite gaining access to the body by this means is quite worth careful attention and inquiry. There is no doubt that the history of Military Hygiene records several instances of stations undergoing marked improvement, as regards the prevalence of malaria, following on the purification of water-supplies. The classical case of the *Argo* used formerly to be quoted as an example of water-borne malaria, but the high death-rate rather raises the suggestion that the water was the means of conveyance of some other form of disease. In spite, however, of what appears to be a reasonable doubt, the incident is, on the whole, worth quoting: 'One hundred and twenty soldiers embarked on this vessel at Bona, in Algiers, for Marseilles. During the voyage 111 of them, 13 of whom died, suffered from different forms of malarial fever. Two other vessels, carrying between them 680 soldiers, also from Bona, and arriving at Marseilles the same day as the *Argo*, had no cases of illness at all, and the only ascertainable difference of the circumstances between the troops in these ships and those of the *Argo* was the difference of drinking-water. The latter were exceptionally supplied with water, which was said to have an unpleasant smell and taste, from a marsh near Bona. Those in the other ships were supplied with good water. Finally, the nine soldiers on the *Argo*, who escaped, were said to have purchased wholesome water from the crew of the vessel.'

* Scientific Memoirs by the Officers of the Medical and Sanitary Departments of the Government of India, 'Malaria in India,' by Captain James, I.M.S., p. 52.

Before leaving the subject of malaria, some points in connection with difficulties of diagnosis need mention. One is the great difficulty sometimes found in differentiating between cases commonly known in the West Indies as 'bilious remittent' and yellow fever.

The former condition is certainly a manifestation of malaria, but in its initial stages it may be quite easily confounded with the more serious form of mischief.

In addition to consequences affecting individuals, uncertainty in these cases may be absolutely inconsistent with the welfare of the public services. I can recall an instance of the above kind, in which a troop-ship came within measurable distance of being placed in quarantine for a case which was ultimately proved, as conclusively as clinical signs are capable of proving anything, to have been malaria, although in the initial stages it was impossible to form any decided opinion.

The difficulties in this direction have made themselves felt by the medical officers of the United States Army, as shown in the annual report of the Surgeon-General to the Secretary of War for 1899. The following extract from the report in question illustrates this point: 'Cases were occasionally observed which, occurring in a yellow-fever district, and in the absence of microscopic examination of the blood, would have been consigned to the wards of the yellow-fever hospital. Thus, Major John T. Gibbons, Surgeon 47th New York Infantry, and Post-Surgeon, Fort Adams, R.I., reported that on September 27, 1898, a man belonging to Battery E, 4th Artillery, who had contracted malarial fever while on service in Cuba, was brought to the post hospital at sick-call. The man had been seen to vomit a coffee-ground liquid. He was much exhausted; temperature 103·7°; conjunctiva yellow, and tongue pointed, red, and quite unlike the ordinary malaria tongue. He was immediately isolated as a yellow-fever suspect; but as the urine was not albuminous, and as the malarial organism was discovered in the blood, the case was regarded and treated as one of æstivo-autumnal fever. Under the influence of quinine the tem-

perature fell, although the patient remained anæmic during a prolonged convalescence.'*

The utility of microscopic diagnosis in cases of the above nature is evident.

It would be out of place here to consider how far yellow fever and malaria may be pathologically related. It is significant that, by means of brilliant work carried out by the Americans in Cuba and Havana, mosquitoes of the genus Stegomyia are now known to be carriers of the actual germ of the former disease. The credit of the earlier of these investigations must for ever be associated with the name of Major W. Reed, United States Army. It is highly probable that many cases diagnosed as malaria are actually due to the parasite of kala-azar. The latter, as is well known, has been investigated by Lieutenant-Colonel Sir William Leishman, and for medical officers serving in some of our foreign stations an excellent opportunity is ready to hand for throwing light on a problem with which the name of an officer of the medical department is honourably associated.

* Report of Surgeon-General United States Army for 1899, p. 296.

CHAPTER VI

PLAGUE

So much has already been written on the subject of plague by those whose experience qualifies them to speak with authority that it may seem an act of presumption to attempt, in the absence of exceptional opportunities for observation, to make an addition to the stock of information already in existence. It may, however, be of some use to medical officers and others if an endeavour is made to select from the general mass of ascertained facts certain points which appear to have a particularly practical application.

It is a matter of common knowledge that the disease exists in two forms—viz., the pneumonic and the bubonic—the nature of each being broadly expressed by its name. The vital cause is the *Bacillus pestis*; the organism has a predilection for rats, and in bubonic plague spreads from the rat to the human being solely by means of fleas.

The findings of the Plague Commission as affecting the above means of spread have been summarized in a most masterly manner by Major G. Lamb, I.M.S., under the title of the 'Etiology and Epidemiology of Plague'; and the seasonal incidence is well shown in a report by Dr. Bruce Low on the 'Progress and Diffusion of the Plague throughout the World' in 1907.

The following tables from Dr. Low's report show the figures for the provinces of Bengal and Madras and Bombay, and for the Punjab.

THE PRESIDENCY OF BOMBAY. POPULATION (CENSUS OF 1901), 25,468,209.

1907.	Plague Attacks.	Plague Deaths.
January	12,446	9,249
February	15,726	12,373
March	28,458	18,072
April	14,920	10,663
May	5,512	3,733
June	3,035	1,829
July	4,575	4,132
August	15,206	10,865
September	33,359	26,908
October	39,203	30,847
November	25,373	13,417
December	6,988	5,707
Total in 1907	204,824	147,795

THE BENGAL PRESIDENCY. POPULATION, 49,891,164.

1907.	Plague Deaths.
January	5,501
February	10,949
March	23,970
April	30,970
May	8,078
June	894
July	306
August	448
September	486
October	313
November	468
December	1,219
Total in 1907	83,602

MADRAS PRESIDENCY. POPULATION (1901), 42,397,522.

1907.	Plague Attacks.	Plague Deaths.
January	100	84
February	140	105
March	111	76
April	53	45
May	23	23
June	69	41
July	119	91
August	303	232
September	889	792
October	704	578
November	667	400
December	509	405
Total in 1907	3,687	2,873

PUNJAB. POPULATION (1901), 24.533,088.

1907.	Plague Attacks.	Plague Deaths.
January	23,375	19,127
February	44,686	38,660
March	117,270	104,153
April	225,062	201,594
May	252,849	228,410
June	62,223	58,859
July	10,242	9,896
August	897	855
September	928	805
October	1,633	1,309
November	1,795	1,592
December	1,551	1,241
Total in 1907	742,511	666,501

(Thirty-Seventh Annual Report of the Local Government Board, 1907 to 1908.)

The contrast between the above number of deaths and the number occurring in 1908 is most striking. In the latter year the figures are as follows: Bombay Presidency, 27,345;

Bengal Presidency, 15,948; Madras Presidency, 3,358; Punjab, 40,106.*

It is now known, thanks to the work of the Plague Commission, that the bubonic form of the disease in India spreads by the rat-flea, or *Pulex cheopis*, the most commonly affected species of rats being the *Mus rattus* and the *M. decumanus*. Infection can also be conveyed by the common rat-flea of Northern Europe known as the *Ceratophyllus fasciatus*. Experiments in connection with *P. felis* as to its disease-carrying power gave negative results. This is fortunate for the European, as the flea in question is the one found on cats and dogs. The *P. irritans*, which is the flea usually found on man, has, in a very small proportion of experiments, been found capable of conveying the disease. Of the two species of rats named, *M. decumanus* has been found to carry more fleas than the *M. rattus*. This is also to a certain extent fortunate, as the latter rat has a liking for human dwellings, while the former prefers to remain in outbuildings, sewers, stables, etc. *M. decumanus* seems to possess extraordinary powers of climbing and burrowing, and can actually gnaw its way through bricks and concrete. The blood is drawn from the rat by means of the pricker of the flea, and then, by contractions of the surrounding muscles, it is passed down the gullet and into the stomach. The latter is a pear-shaped organ, the average capacity of which is estimated to be about ·5 c.mm., and when distended with blood appears as a bright-red mass, nearly filling the whole of the abdomen. The blood of a plague-infected rat may contain about 100,000,000 bacilli per cubic centimetre, so it is very plain that the stomach of the flea can contain a relatively large number. The bacilli, having passed through the remainder of the alimentary canal, are extruded *per rectum*, and then gain entrance to the body of their victim either by the pricker of the flea, or else by being rubbed, by the hand, into the wounds made by the pricker. It also seems that the flea, while sucking, is in the habit of squirting blood from the anus.

* Report on the Progress and Diffusion of Plague throughout the World in 1908, by Dr. R. Bruce Low (Thirty-Eighth Annual Report of the Local Government Board, 1908 to 1909).

Infection from soil, water, food, or air can practically be excluded in the case of bubonic plague, but in the pneumonic variety infection by inhalation is an undoubted means of spread. Fortunately, pneumonic plague is rare, and is stated to form only about 3 per cent. of all cases.

We can now perceive an easy explanation of the rise and fall of the disease according to the season of the year, for it needs no great effort to trace a connection between the presence of vermin of all sorts and the horribly insanitary condition of the low-class Indian dwelling during the months when the wretched inhabitants remain huddled together in a state of hopeless squalor and discomfort which can best be pictured by a diseased imagination.

In the army in India the usual source of mischief is in the followers' huts. These are generally inconceivably foul— in fact, with all the care in the world, they would be very difficult to keep clean. Cow-dung and mud form a combined basis for the construction of these miserable hovels; there is nothing worth calling ventilation, and the usual absence of windows excludes the sunlight, together with the purifying effect which the rays would have. The roofs commonly consist of bazaar tiles; as the tiles are excellent conductors of heat, they are about the worst imaginable protection against extremes of temperature. The inhabitants consist largely of syces and sweepers, both low-class Hindus, and often given to drink. The duties of the sweeper are of the most degrading kind, as, besides those which his designation suggests, he is the remover of the receptacles containing night-soil from latrines and bathrooms, and he conveys on his person and clothes the relics incidental to his fetid calling. Ablution arrangements, as the term is usually understood, are entirely absent; such water as is used for washing and other purposes is conveyed to the quarters in a 'mussack.' In cantonments latrine accommodation consists of galvanized iron screens separated into compartments and provided with receptacles which are removed by the sweeper. The ground is usually horribly fouled by splashes of urine and fæces. These structures, which are

also common to the civil population, are known as 'pukka' latrines. The 'kucha' latrines are simply shallow excavations, dug without the least regard to the contamination of soil or water. In the slums of a large city I have seen the latter form of latrine actually in the interior of dwellings. Whether this is common throughout India I do not know. The 'kucha' latrine is, of course, not tolerated in the regimental lines. Except so far as occasional latrine accommodation of the foregoing nature is concerned, the above surroundings of the native follower are the same in most respects as those of other natives of the same class. In the hot weather the nights are spent outside the huts, so that the sleepers are not subjected to the evil effects of the interiors, but as the cold weather advances sleeping in the open comes to an end, and the nights are passed under conditions which, according to all experience, must be directly productive of more than one form of disease, and the association of plague with the colder months of the year has long been known—in fact, the foul, unventilated, reeking native dwelling is, for practical purposes, the medium in which the plague bacillus is evolved.

Vermin and dirt are, generally speaking, inseparable, and until the whole manner of the low-class Indian life is altered rats and fleas will continue to flourish. A personal experience has brought this fact home to me. I was invited by an Indian practitioner to accompany him on a visit to a slum in the native city of Meerut, and I came away with a feeling of considerable surprise, not that the people died rapidly, but that any of them were left alive.

The effect of temperature on fleas and bacilli is a factor of vital importance. The findings of the Commission in regard to this matter are as follows:

'TEMPERATURE.

'(*a*) A high mean temperature—*i.e.*, 85° F. and over—affects the fate of the plague bacillus in the stomach of the flea. At this temperature fewer successful transmissions from animal to animal are obtained, and, besides, the flea

does not retain its power of infecting nearly so long as it does at a lower temperature—*i.e.*, 70° F. At the higher temperature the plague bacilli disappear from the stomach much more quickly than at the lower temperature.

'(*b*) While a mean temperature, high in comparison with 70° F., has no effect on the number of plague-infected rats which contain bacilli in the blood at death, at a low mean temperature, such as 50° F., the number of infected rats that die before bacilli appear in the blood is much greater than at the higher temperature—*i.e.*, 70° F.

'(*c*) Temperature may have an influence on the prevalence of fleas in nature. It has been shown that a high temperature affects the breeding of fleas to a considerable extent. It appears not only to restrain the adult from depositing eggs, but also to deter the development of the eggs into larvæ.

'4. Finally, from a study of the climatic conditions and epidemic plague in six places in India it appears that plague cannot exist in epidemic form in any place when the daily mean temperature is high, *i.e.*, 85° F. and over. In some places the rise of the mean temperature to this degree and the fall of the epidemic coincide, while in other places, *e.g.*, Belgaum and Poona, the epidemic subsides when the mean temperature is most suitable, namely, about 70° F. Another factor or factors must, in these instances, be in operation in causing the decline of the epidemic.

'In the Punjab during the winter months a low mean temperature, such as 50° F., insomuch as it diminishes the number of infected rats which contain plague bacilli in their blood at death, may be a factor in limiting plague outbreaks.

'We find, therefore, that the epidemiological facts are in harmony with the experimental data as far as temperature is concerned.

'VARIATION IN THE NUMBER OF FLEAS.

'It is not only *a priori* certain, but it has also been experimentally proved by the Commission, that the rate of progress of a plague epizootic is in direct proportion to the number

of fleas present. The questions, therefore, to be answered are: (*a*) Is there in nature a seasonal variation in the number of rat-fleas? and (*b*) if so, does it correspond to the rise and fall of the plague epidemic? The Commission have obtained answers to these questions. In Bombay and in the Punjab it was found that there was a very definite seasonal prevalence of rat-fleas. And it was further found that the plague epidemic season corresponds with the greatest prevalence of these fleas, while in the months when plague is at its minimum the fleas are fewest in number. No direct evidence was obtained to show what factors are concerned in this variation in the flea prevalence, except the few temperature experiments already mentioned.'*

With reference to the plague in Kashmir, the following remarks are found in the Report of the Sanitary Measures in India, 1901-1902:

'The epidemic was at its worst in the months of November and December. It is stated that infection was generally observed to pass readily from patients to their attendants or visitors, so long as the former remained in their dark and ill-ventilated houses, but that after their removal into tents or "chuppars" in the open, the number of attendants who took the disease from their sick charges was strikingly insignificant. About twice as many women were affected as men, which was ascribed principally to their being more in the house than men.'†

In its causal relationship to dirt, overcrowding, and foul air, plague closely resembles a condition with which it has also many points in common—viz., typhus fever. It is known that the poison of typhus fever, whatever it may be, tends to be localized in the immediate neighbourhood of the sufferers, and that its power for evil is commonly destroyed by fresh air and cleanliness. It is certain that Western races suffer severely from typhus fever, and although they rarely contract Oriental plague, they are by no means immune to it.

* 'The Etiology and Epidemiology of Plague,' pp. 88-90.

† Report of Sanitary Measures in India, 1901-1902, p. 103.

It is impossible to say whether the epidemic which devastated London in 1665 was actually identical with what is known, at the present day, as Oriental plague, or whether subsequent outbreaks in other parts of Europe were of the same nature. But even assuming that the disease, as it now exists, has never spread widely in the Western Hemisphere, we have quite enough evidence, if not from India, at any rate from China, that the white race is distinctly liable to infection.

The question of susceptibility is well worth dwelling on, as it bears on the true cause of the disease; for if the idea of comparative immunity is once banished, we come face to face with the question as to why the condition is principally limited to one section of the population, when all are equally receptive of the poison. By keeping the possibility of infection in mind, we get rid of the mischievous idea that plague is due to a bacillus which almost completely limits its attacks to the Eastern races, and that, as it is never likely to prove serious to European nations, we can view its presence with comparative equanimity. There are good reasons why the question may be fairly raised as to whether the European really enjoys any immunity at all. Even among natives a history of immediate contact with sick can generally be traced, and the usual mode of life makes the frequent transference of body vermin a matter of practical certainty. At Meerut the plague hospital is surrounded by the dwellings of a low-class population, but instances in which disease has spread from the institution to the outside community are unheard of. Nor is there any evidence that native hospital assistants and others engaged in plague duty, but who are not exposed to the immediate contact which prevails among dwellers in the same room, show any particular liability to infection. Having regard to the conditions of daily life to which the poorer-class natives are subjected, it is certain that, when sickness occurs in their families, the term 'contact' must never be taken in its most literal sense. Europeans are practically never brought into such intimate association with the disease as that which obtains in the

case of natives, so that the comparative immunity of the former may be more apparent than real. The evidence concerning the insusceptibility of Europeans is naturally of a negative character only, as opposed to positive evidence pointing in the opposite direction ; and when the differences which exist in mode of life are considered, it becomes very doubtful whether the prevalence of the disease among the native population is not principally the result of conditions which do not apply to the Western race.

The Plague Commission attributes the apparent immunity of Europeans to the fact that sanitary conditions and a decent standard of comfort are inimical to the presence of rats in dwellings.

'Incidence of Plague on Different Classes of the Community.

'It has been the general experience in India of all plague-workers that the incidence of the disease is not so great amongst the well-to-do classes as amongst the poorer population. Europeans are practically exempt. The Commission's experience bears this out, and certain statistical data which they collected are in harmony with it. The explanation is not far to seek. The description of the houses and habits of the people which we have given above apply only to the poorer classes. As the people rise in the social scale, their houses are of better structure, and, more important still, their mode of living becomes more like that of the Europeans. The compounds of the houses are kept clean, and the household rubbish which accumulates is relegated to a godown. There is, therefore, little or no shelter or attraction for rats. Further, the people themselves, like Europeans, show much aversion to live in association with rats. It can, therefore, be readily understood that the houses of the well-to-do Indians in a city such as Bombay, as well as the houses of the Europeans, do not harbour anything like the number of rats which are to be found in the houses of the poorer population. It would

appear, in consequence, that the explanation of the fact that the incidence of plague is much greater on the poor population than on the well-to-do Indian and European is ultimately found to be in the different conditions in which they live and in their different habits.'*

It has already been remarked that an outbreak may often be traced to the dwellings of the native followers. These persons bring into the regimental lines the disgusting habits of the city and the bazaar, and, not being subjected to military discipline in the usual meaning of the term, they have not the advantage of the enforced cleanliness which is found among soldiers. It is a remarkable circumstance, as bearing on this point, that the men of native regiments remain free from the disease at a time when it is rife among the followers. Again, the disease is comparatively rare among the servants of the Europeans, and here, also, the influence of environment seems to have a decided effect. Of course, both native soldiers and servants constantly frequent the bazaar, besides visiting their own homes, so that, although doubtless far better placed regarding liability to infection than the poorer section of the community, they are exposed to risks from which the European is almost entirely free. Cases occur to me in which plague was certainly conveyed into cantonments by servants who had contracted the disease when visiting relatives. Ayahs are a serious cause of danger. These women are almost entirely drawn from the sweeper caste, so that their family connections are not likely to necessitate an exceptionally high standard of cleanliness or refinement.

One great difficulty in dealing with outbreaks of plague is caused by the insidious manner in which the disease makes its appearance. It is an extraordinary circumstance that many of the patients in whom the malady is rapidly nearing a fatal issue appear, on casual inspection, to have nothing the matter with them. I believe that attention has already been drawn to this fact by Mr. James Cantlie. Natives very often change their residence on the very day before they die,

* 'The Etiology and Epidemiology of Plague,' p. 75.

and I have been informed by the medical officer in charge of the Cantonment General Hospital, Meerut, that he has known a man to leave the hospital and walk about the streets on the afternoon of his death. It is, in fact, impossible to avoid being struck with the appearance of well-being which the patients often present.

The possible consequences of the above peculiarity are obvious, and examples from actual occurrences show the way in which the danger presents itself. An officer found a strange boy asleep in his stable, and on inquiring the reason, was informed by the syce that the boy, who was a relative of his, was not feeling well, and had come in to lie down. The boy, having expressed his regret for an act of trespass, went away, apparently having nothing the matter with him. He died next day of plague.

The bearer and khitmutgar of an officer complained for a few days of general malaise. The man was an old and faithful servant, and his employers left him to carry out only the duties that he thought fit, and attended generally to his wants. They were entirely under the impression that he had very little wrong with him, when he died suddenly of plague.

Many such other instances could be related, the general moral of which is to take immediate steps for a careful examination of all native servants suffering from indefinite illness, particularly when plague is known to be in existence.

Another difficulty is supervision of the native followers. It has previously been explained that these persons live under approximately the same conditions as other natives of the same class, and all the inspection in the world will not keep such people up to anything approaching a satisfactory standard of cleanliness. In fact, it would be a difficult task to keep clean, even with the best will in the world, when residing in a hovel constructed of cow-dung and mud, and which is unprovided with light, ventilation, or water, and with personal effects, in the way of clothing, comprised in a handful of decomposed rags.

By taking immediate precautions when dead rats are

noticed, an outbreak of the disease may be prevented. An officer commanding a battery of field-artillery made this warning a ground for the evacuation and disinfection of the huts in his syce lines, with as complete a destruction of rats as was possible. Plague broke out shortly afterwards in the cantonments, and although the followers of other units were attacked, the natives in his own lines remained free. He informed me that the measures had been carried out entirely on his own initiative.

Squirrels are a common feature in many parts of India, notably in Bengal and the Punjab. They are very easily tamed, and are occasionally kept as pets. It is believed that plague has been conveyed by the bites of these animals when suffering from the disease. Like dead rats, dead squirrels should be regarded as a warning of danger. The importance of destroying the bodies of either squirrels or rats is not always appreciated. The bearer of an officer died suddenly from plague, and the same day several dead squirrels were found on the roof of the bungalow and behind the creeper on the walls. Two more cases of plague occurred among the servants, and both proved fatal. Although there was no conclusive evidence connecting the discovery of the squirrels with the sickness among the servants, the incident is sufficiently suggestive to be worth recording.

The common circumstances of native life are an almost insuperable barrier to the detection of early cases of plague. Besides the hopeless ignorance of the lower classes, distrust of the good intentions of the European makes recourse to quack methods almost certain in cases of any kind of illness. Every town swarms with native practitioners of the shadiest antecedents, and it is on these men that the poorer classes commonly pin their faith.

Nothing which corresponds to a parish doctor exists, and death-certification, as understood in England, is impossible. Responsibility is covered by notification to the police. The dread of removal to a hospital is a direct advantage to the specious impostor, who trades on the credulity and ignorance of his victims. Even if he is aware of the nature of the

malady which he purports to treat, it would not be to his interest, if a case happened to be one of plague, to notify it as such, for in so doing he would lose the confidence of those on whom he depends for a living. It thus happens that, if plague breaks out in a crowded community, the prompt detection and isolation of the earlier cases may depend entirely on the personal interests of a rapacious and ignorant rogue.*

It is, therefore, quite impossible to form any sort of estimate of the number of deaths which are reported as due to fever or other cause, being actually cases of plague. The only cases which stand a good chance of detection are those which have been seen by the plague officer, and as he can only visit when the necessary information is supplied by the civil authorities, or, more rarely, by the patient's friends, his sphere of usefulness is unfortunately restricted.

It is plain from the statements that the occurrence of plague among natives may be expected at almost any time, although, for reasons already given, the probability of this advent is far greater in the cold season.

Vigilance directed towards syces, sweepers, and the like, is not thrown away. The native hospital assistants, no doubt, maintain excellent supervision over followers, and without wishing in any way to decry the work which these men so faithfully perform, it can never be forgotten that their powers of detecting the nature of the disease is far removed from those of the trained and educated European. The hospital followers may, in the absence of efficient supervision, be the origin of the gravest mischief, and I have myself known a case, which should certainly have been immediately reported to a medical officer, improperly detained and ultimately removed to the cantonment hospital as plague.

The regimental medical officer is often asked to decide as to whether a unit in which plague has occurred should be

* These remarks are, of course, in no way intended to be offensive to the many honourable members of the medical profession found among natives in India, but only to men who pose as belonging to a calling with which they have no legitimate connection.

allowed to leave any given station. For this purpose there should have been no cases for a minimum period of ten days. This rule causes a good deal of unavoidable inconvenience. Officers and men, having prepared for departure, find their arrangements upset by the occurrence of a fresh case. If a medical officer new to the service and recently arrived in the country gives his sanction to proposals framed with a view to convenience rather than safety, he may, in this connection, bring about a web of official complications from which escape is a matter of considerable difficulty, and this distinct from public consequences of a disastrous nature.

As previously stated, it is essential to inspect the followers' lines and the followers' hospital constantly, as, apart from the early detection of cases, this practice keeps the hospital assistant well up to his work. In general terms, cases of high temperature, accompanied by swollen lymphatic glands, are plague. Of course, other causes for the glandular enlargement and high temperature must be carefully sought for. Pneumonia also, in natives, particularly in the winter, should be looked on with great suspicion, and the sputum always microscopically examined. The physical signs are frequently indistinct in cases of pneumonic plague. As in other diseases, diagnosis can only be satisfactorily learnt by experience. Any suspicious cases should be isolated at once in a tent, and during the period of isolation the excreta should be sterilized. Native hospital assistants sometimes try to carry out this measure by mixing the excreta with dried mud, and then burning the mass. It is a filthy plan, besides being dangerous. Boiling is comparatively clean, and absolutely certain in its results. Both urine and fæces may contain the bacilli in large numbers, but the experiments of the Plague Commission do not point to the above as a frequent source of infection.

The average incubation period is stated to be three days, but a wide margin of safety should be allowed.

'Charpoys' should be burned. It is common to find that the strings only are burned, and the woodwork is passed through a flame. As the whole structure may be valued at

about a rupee (1s. 4d.), it might just as well be destroyed. Clothes should be burned, the quarters fumigated, and the roof afterwards removed. Sulphur is often used for purposes of fumigation, but some more modern method would be desirable. Spraying the walls of dwellings with perchloride of mercury (1 in 1,000) is one stereotyped means of disinfection. It has already been stated that the habitations of the poor are partly constructed of cow-dung, and the albumin contained must therefore render the good efforts of the mercurial solution doubtful. The Plague Commission, however, found that a solution of 1 in 750 was efficacious in killing the plague bacillus, even in the presence of organic matter. Cyanide of mercury mixed with kerosine oil has given good results as a pulicide and disinfectant.

It is satisfactory to know that the Commission found no evidence that man harbours the bacilli after recovery from the disease.

The wholesale destruction of rats has been attempted by the Danysz bacillus, one of the typho-colon group. These results have not been encouraging. Another virus, known by the name of 'Ratin,' has also been used, but, as in the former case, without real success.

The keeping of cats in the houses has been recommended, and the Salvation Army proposed exporting a shipload of cats to India to deal with the rat by means of its natural enemy. As none of these measures can alter local circumstances, it is clear that they leave the root of the mischief untouched.

If, however, we are unable to make any immediate and material change in old-standing conditions, we can mitigate the results flowing from such conditions, and for this object preventative inoculation may be accepted, if not as a complete mainstay, at any rate as one not to be despised.

The vaccine commonly used is that prepared by Haffkine. It partly consists of an intracellular poison administered on the same principle as in antityphoid inoculation—in other words, of a poison contained within the bodies of the bacilli which have been killed by heat. The temperature employed

is from 50° to 55° C., and is maintained for fifteen minutes. This has the effect of destroying the life of the germs without destroying the contained poison. The cultivation is carried out in broth, with the object of obtaining an extracellular as well as an intracellular poison. In the words of Haffkine, in reference to the germs, 'the concentrated products of their activity' are introduced into the body as well as the germs themselves. It will be seen, therefore, that the method differs from antityphoid inoculation, in that it comprises bacterial products besides the contents of the bacterial forms. Some results of Haffkine's methods are set forth in the following table :

Statistics of Haffkine's Preventive Inoculation.

Place.	Number of Persons.		Number of Cases of Plague.	Number of Deaths from Plague.	Mortality per Cent.
Mora	Non-inoculated	581	26	24	—
	Inoculated	419	7	0	—
Damaun	Non-inoculated	7,213	—	716	9·9
	Inoculated	1,017	23	6	0·58
"	Non-inoculated	5,869	—	674	11·15
	Inoculated	1,639	64	27	1·6
"	Non-inoculated	4,643	—	93	2·0
	Inoculated	2,164	4	3	0·14
Kirkee	Non-inoculated	859	143	98	11·4
	Inoculated	671	32	17	2·5
Khoja community of Bombay	Non-inoculated	9,516	—	77	—
	Inoculated	3,814	—	3	—
Hubli	Non-inoculated	17,786	—	2,348	—
	Inoculated	24,631	—	338	—
					Case Mortality.
Dharwar	Non-inoculated	16,848	1,100	889	80·8
	Inoculated	4,321	129	54	41·8

('The Bombay Plague,' by Captain Condon, p. 35. See also article by Monckton Copeman, *Journal of the Royal Institute of Public Health*, October, 1909.)

The period of protection after two inoculations is probably about one year.

Plague in India is inseparably bound up with the habits and customs of the people, and although, with reasonable precautions, it never spreads among Europeans, the possibility of outbreaks among the latter must be reckoned with for generations to come. In future years the disease may perhaps be effectually dealt with, but at present ignorance, poverty, caste prejudices, and religious customs all combine to make the task almost impossible. It is therefore well to consider plague as omnipresent, and to take precautions accordingly.*

* The Sanitary Commissioner for Bengal quotes Major Gwyther, I.M.S., as stating that the recently improved situation cannot be ascribed to sanitary effort, but rather to scarcity of food for human beings, and consequently for rats (Annual Report of the Sanitary Commissioner for Bengal, 1908).

CHAPTER VII

PNEUMONIA—CONTAGIOUS OPHTHALMIA—DENGUE—JAUNDICE

PNEUMONIA

UNDER the heading of pneumonia are grouped together conditions which, pathologically, have little or no connection one with the other except in so far as a common seat of mischief—viz., the lungs—is concerned. At present only the disease known as acute lobar pneumonia needs consideration. There is strong evidence to show that the vital cause of this condition is to be found in the diplococcus of Fränkel and Weichselbaum, and it is of great interest to note that the bacillus cannot always be distinguished from one which is often present in healthy saliva. This fact may possibly serve as the explanation of some outbreaks of pneumonia in which no antecedent cause can be traced.

Disease as a whole may be deemed a 'variation' in the ultimate living constituents of the animal body, and Darwin has affirmed that variation is dependent on two factors—namely, 'the nature of the organism and the nature of the conditions.'* Thus it may be that the bacillus present in the healthy buccal cavity can produce in lungs which have sustained some form of injury—either by gross traumatism, the inhalation of irritating matter, cold, etc—those changes which constitute the condition known as pneumonia; thus illustrating the occurrence of variation resulting from modification in the receptive organism. There is no doubt, on the other hand, as to pneumonia being caused by the

* 'Origin of Species,' chap. i.

attack of a specific germ; but this fact does not exclude the possibility of the above theory being correct. The classical instance of the Middlesbrough epidemic should satisfy the most incredulous of the existence of an organism capable of setting up the disease. It is also equally certain that cases are constantly met with in which no cause in the shape of antecedent existence of the malady is to be found.

Outbreaks constantly take place under conditions of foul air and overcrowding. Whether the pulmonary tissue is altered by the inhalation of noxious products, with possible results already indicated; or whether the invading germ acquires pathogenic powers in a manner somewhat akin to that suggested in the case of enteric fever, and attacks the body with its capabilities fully developed, are only matters for speculation. The subject is full of practical interest, and the assumption of the truth of one or other of the above theories leads to those measures of prevention which are the most likely to be followed by beneficial results. Military medicine can produce numerous instances of pneumonia occurring *de novo* under insanitary conditions. In the winter of 1899 to 1900, when troops were being hastily despatched to South Africa, large numbers had of necessity to be carried in the transports, and outbreaks of pneumonia might reasonably have been anticipated. The season was that in which a vessel running South has a particularly long spell of a following wind in the shape of the north-easterly trades, and a correspondingly short spell of the head-winds in the Southern Hemisphere. In the vessel in which my unit sailed, pneumonia broke out between decks shortly after we had left St. Vincent. Up to that time there had been no indication of acute specific sickness amongst the troops; and as we had been fully ten days at sea before the first case occurred, it is certain that the disease was not brought on board at the port of embarkation. We had coaled at St. Vincent, but the men had not been allowed to leave the ship, so that introduction from the shore can, as in the former case, be negatived. All available space on board was occupied, and the heat and foul air below were intensified

by the direction of the wind. Cases followed each other in rapid succession until we were some few days south of the line, and had met the south-easterly trades. It is difficult to describe the marvellous change in comfort which instantly made itself felt. A current of fresh air swept through the ship from stem to stern, and life, even between decks, assumed a new aspect. No more cases, to the best of my recollection, occurred during the rest of the voyage to Durban. The disease came into being when heat was greatest and ventilation was worse, and it died with the advent of a steady supply of fresh air and a rapid fall in temperature (see pp. 266 and 390).

Dust is sometimes a cause of pneumonia, but the exact pathology of its mode of action is unknown. In the early summer of 1889 three militia battalions arrived at Colchester for their annual training. One battalion was camped on a grassy plain known as the Abbey Field, and the other two battalions were located—also in tents—within the precincts of the barracks, on a dusty parade-ground enclosed on two sides by a high wall, and in the immediate proximity of the regular troops. The position was not the best from a sanitary point of view, being too much closed in and undesirably hot. Pneumonia broke out in these two battalions in a severe form. Unfortunately, I am unable to state the percentage of attacks to strength, but, speaking from memory, it was alarmingly high. Only one case occurred in the battalion camped on the Abbey Field. The latter locality was all that could be desired, and it is consequently fair to accept the extreme probability of the outbreak having been caused by the surroundings of the two regiments in barracks. The regular troops, who were in huts, and, comparatively speaking, protected from the dust, escaped, as far as I can remember, entirely.

Pneumonia among troops is sometimes connected with defective drainage, and as evidence in support of this statement there occurs in the Army Medical Report for 1886 an account by Surgeon-Major (now Surgeon-Lieutenant-Colonel) G. S. Robinson, 2nd Scots Guards, of an outbreak in March

to May, 1885, amongst the men of his regiment, which was stationed at the time in the Richmond Barracks, Dublin. The drainage of the barracks was defective. The following is a statement from an official source of some of the defects which were present :

'*November* 25, 1885.—Drain in front of C passage, married quarters, smelling offensively. Many complaints made by families living in this passage about the smell.

'*November* 30.—This drain partially opened, and found to contain solid sewage to a depth of 6 inches throughout its entire length.

'*December* 3.—The Royal Engineer Department, on opening up drains round the married quarters, found them all more or less stopped up with semi-solid sewage.

'*December* 12.—Drain leading from canteen crosses road, and goes underneath the men's barrack-rooms. It has not yet been found coming out on the other side.

'*December* 26.—Main drain across barrack square is being opened and cleansed; in many cases it contains a deposit of semi-solid sewage to a *depth of nearly* 2 *feet*. Found a large hole made up with masonry, and containing a quantity of black-coloured semi-fluid substance, behind officers' mess. Seems uncertain what this place has been, an old well or a cesspool !

'Find a drain running from the urinal under the clock-tower in front of the E block of barrack-rooms, which, when opened up, was found to *contain much* semi-solid matter.'*

The state of affairs resembled that which is often associated with enteric fever, and it is important to note, as shown by the figures set forth on p. 142, that several cases of simple continued fever, so called, occurred at the same time as the outbreak of pneumonia. The latter disease was not prevalent in Dublin, so that there was strong reason to connect its presence with some local cause. In 1885 the sanitary defects were removed, and though the good results were not immediately apparent, probably owing to soakage of filth from the drains into the soil, no mention is found

* Army Medical Report, 1886, Appendix XII.

in the report of 1887 of any excessive illness at these barracks.

	Admissions.	Average Duration in Days.
1884.		
Pneumonia	36	34·7
Enteric fever	2	53
Simple continued fever ...	13	13·3
1885.		
Pneumonia	13	42
Enteric fever*	2	22†
Simple continued fever ...	24	13·4
1886 (first half of year only).		
Pneumonia	8	33·7
Enteric fever	Nil	Nil
Simple continued fever ...	25	12·2

This table points strongly in the direction of a common origin for the cases of simple continued fever and those of pneumonia. The possible connection between the former and enteric has already been discussed, and it is interesting to see that this theory receives support from the history of the outbreak recorded by Surgeon-Lieutenant-Colonel Robinson. The general conclusions which he arrives at are as follows, and though not absolutely in accordance with present beliefs, yet, from a practical point of view, they fully deserve careful study:

'1. Pneumonia may be of three varieties—

(1) Simple or sporadic, the result of exposure to cold winds, etc.

(2) Infectious, the result of contagion.

(3) Pythogenic, the result of impure air or gases.

'The outbreak at Richmond Barracks was not due to cold winds, etc. (as believed by some), because pneumonia was

* There were six other admissions, three being fatal, which occurred in men who had served in the Soudan campaign, 1885.

† One fatal in four days (Army Medical Report, 1886, Appendix XII.).

not specially prevalent in Dublin at the time. Surgeon Carte, Coldstream Guards, at that time Acting-Surgeon to the Royal Military Hibernian School, and also doing duty at the Royal Hospital, Kilmainham, writes: "The number of cases of pneumonia in Dublin in 1884 did not exceed the usual average. I myself had charge of the adjacent Royal Hibernian School (600 strong) that year, and had only two or three cases; also of the Royal Hospital, Kilmainham, and of Kilmainham Gaol, and saw very little of the disease." It was not infectious, because it did not spread in hospital or elsewhere. There is strong presumption, from the nature of the epidemic and the insanitary conditions shown to exist, that it belonged to the third class.

'2. Pythogenic pneumonia, then, as already defined, is a general disease of septic origin, the lung affection being "the local expression of a general disease, of which it is not necessarily the measure." The poison appears to be absorbed directly into the blood through the medium of the lungs, thus explaining the short period of incubation. In slight forms pyrexia, headache, and vomiting are produced; in more severe forms the lung tissue is especially attacked.

'3. There does not appear any reason why the special contagia of the infectious form should not be also present in some epidemics in which the disease is more severe and there is a period of incubation, the result resembling the pneumonia of enteric fever.

'4. Finally, the same gases, contagia, etc., being absorbed by water and so entering the intestinal tract, may produce ordinary enteric, named by some pythogenic fever.

'5. There is, therefore, distinct relationship between the three diseases, simple (so called) continued fever, pythogenic pneumonia, and enteric fever; and for purposes of classification I should propose to return all three under the heading of "pythogenic fever," the pulmonary or intestinal manifestation depending on the mode of attack.'*

Wasden and others have suggested a similarity of origin for enteric fever and pneumonia, and I have seen the latter

* Army Medical Report for 1886, Appendix XII.

break out in a fatal form in Upper Egypt, in a camp where the soil was horribly foul and where enteric fever was rife. I must at the same time admit that the extent of the sickness was sufficient only to justify its presence being regarded in the light of incidental evidence.

In the interests of the public service it is better to over-estimate, rather than to underestimate, the possible effects of local insanitary conditions on the health of troops. The greater the number of diseases which can be included under the general heading of 'filth-borne,' the greater is the stimulus to sanitary efforts. By calling attention to all reasonable possibilities, we guard against sickness which might assail us if we neglected to take precautionary measures in the absence of positive and conclusive evidence of the presence of danger.

Whenever possible, cases of pneumonia should be isolated, the sputa and excreta destroyed, and all the usual means of disinfection put into force. The danger of pneumonia among natives of India has already been mentioned. It should never be forgotten that pneumonia may be associated pathologically either with enteric fever or plague, and this connection justifies the usual steps of watchfulness and precaution.

CONTAGIOUS OPHTHALMIA.

Contagious ophthalmia is fortunately not often seen in the service at the present day. The most severe outbreak of the kind that I ever saw was in a company of Mounted Infantry proceeding up the Nile in the autumn of 1885. A man reported sick the day after we left Cairo, with profuse discharge from both eyes; I had him sent back at once to the Citadel Hospital, but it was too late to stop the mischief. The journey to Wady Halfa extended well over a month, and during that time, as far as my memory serves me, about 50 per cent. of the men must have been attacked. There were no means of effecting anything worth calling isolation, and as the men occupied a limited space, and constantly used each other's towels and blankets, the disease spread rapidly. One attack procured immunity, at any rate for a

time, and although the men had every opportunity to contract the disease twice, I cannot recall an instance of the kind. The officers, six in number, escaped entirely.

The affection known as granular lids sometimes appears among men in epidemic form, but it is comparatively rare and does not spread with anything approaching the rapidity of the purulent type of ophthalmia. Cases occurred at Korosko during the summer of 1886. The men attacked were promptly treated, and the disease never spread sufficiently to cause alarm.

DENGUE.

Dengue is common in many of our foreign stations, and notably so along the coast-line of Natal. In October, 1901, Bethune's Column was attacked by this disease in the district near the mouth of the Tugela. The column was on its return march from Zululand, and the disease made its appearance when the men had left the healthy and bracing uplands near Eshowe, and had descended to the enervating region of the coast. The disease spread with alarming rapidity, much in the same way that influenza seizes on communities. Unfortunately, there were no means of taking careful records of the cases. The numbers attacked were excessive and the medical officers few. A striking feature in the epidemic was the constant occurrence of small, shotty, and exceedingly painful lymphatic glandular enlargements. As there was a suggestion that the disease might be a mild form of plague, an isolation camp, of which I was placed in charge, was established at Stanger, and all communication, as far as possible, cut off between the troops and the civil population. The unaffected portion of the column continued its march to the Free State. In its clinical manifestations the outbreak was a typical dengue, plus enlargements of the cervical, axillary, and inguinal glands. I have no record of the percentage of the attacks, but it must have been exceptionally high. The average duration was about a week, and the mortality was nil. Had the outbreak occurred under the usual conditions of peace, valuable records would have been forthcoming.

Owing to the researches of Graham in 1903, followed by

those of Craig and Ashburn in 1906, it is now believed that infection is conveyed by a mosquito, *i.e.*, the *Culex fatigans.* Craig and Ashburn were unable to discover an organism, but they succeeded in imparting the disease by means of filtered blood drawn from the sick.

JAUNDICE.

Only deficient knowledge justifies the inclusion of jaundice in the list of specific diseases. Jaundice is, in fact, only a symptom of some other condition ; when the latter is unknown it receives the designation of its external manifestation. It often occurs as an epidemic, and in this form will be considered here. The similarity of surroundings which accompany epidemics leave only slight ground for reasonable doubt as to the origin of the mischief being due to some specific form, possibly related more or less closely to the germ of enteric fever. In 1862 there was a severe epidemic of jaundice at Rotherham. It was stated that in the month of February 150 persons were attacked by it. The drainage of the town was exceedingly bad, and in the autumn of the previous year a very fatal epidemic of enteric fever had visited the locality. It was reported that none of the persons who had been attacked by the disease suffered from jaundice in the ensuing year. If this is true, it suggests the relationship of the two conditions, on the ground of immunity purchased during the earlier of the two epidemics.* According, also, to Sir Thomas Watson, there was an epidemic of jaundice in London at a time when enteric fever was remarkably prevalent.† Dr. F. M. Sandwith states: 'There can be no doubt that it is a filth disease engendered by contamination with sewage and putrid meat. In Alexandria it has become more common since the introduction of a bad system of imperfect drainage, and the bulk of the patients come from the lowest parts of the town, where the drainage is worst, and where the sewers empty into the sea ; yet the suburbs of the town, which are not drained at all, are apparently unaffected. Again, at Smyrna the disease only pre-

* *Lancet,* 1863, vol. i., pp. 222, 374.

† Murchison.

vails in the most dependent parts of the town, where the sewers join the sea, and at Nauplia it has disappeared since iron drain-pipes have superseded badly-jointed stone conduits. In Germany men have caught it after bathing in a river contaminated by sewage, or after eating tainted meat.'*

Lieutenant-Colonel H. B. Mathias, R.A.M.C., states as follows: 'As to the exact causation of the disease, we are still more or less in the dark.'† It has been attributed by Jaegar and Banti in Germany to a 'bacillus,' the '*B. proteus fluorescens*,' but this does not appear to have been confirmed by other observers. Weil himself seems to have been disposed to look on these cases as a modified enteric fever, whilst Chantemesse and other French physicians go still farther, and attribute all cases of febrile jaundice, from the mildest to the most acute yellow atrophy of the liver, to the presence of the typhoid bacillus in the portal system, and have named this disease 'fièvre typhoïde bilieuse.'

All observers are agreed that it is, to a great extent, a filth disease, and is therefore prone to exist where insanitary conditions prevail, and that it is especially prevalent in armies in the field and in standing camps; my experience in South Africa certainly bears out these observations, a large proportion of the cases admitted to No. 19 Stationary Hospital, Harrismith, coming from a standing camp which was notoriously unhealthy, and where some of the worst cases of enteric fever I saw during the campaign were contracted.'

There were also many cases amongst the troops engaged in the operations in Northern Natal in the spring and summer of 1900. The weather was bitterly cold; but although the temperature was probably a factor in producing the symptom, it could not have been the only cause, as ordinary experience of the effects of cold is quite opposed to any such conclusion.

* 'Infectious Jaundice,' by F. M. Sandwith, M.D., F.R.C.P., Lecturer at the London School of Tropical Medicine, Consulting Physician to the Kasr el Ainy Hospital, Cairo (*British Medical Journal*, September 17, 1904, p. 672).

† 'Jaundice in South Africa,' by H. B. Mathias, D.S.O., Major R.A.M.C. (*British Medical Journal*, September 17, 1904, p. 675).

There is no doubt that cold, by causing congestion of the duodenal region, induces jaundice, but certainly not to the widely spread extent that was seen in South Africa. The trouble was very common in the Dundee district, and here enteric fever was prevalent, and many of the camping-grounds were most unhealthy, as a result, probably, of soil pollution. No causal relationship with either food or water could be traced; the condition, in short, appeared to arise under the same surroundings as those which experience shows are commonly connected, in the field, with the advent of enteric fever. It is remarkable, as throwing light on the probable cause, that jaundice in an epidemic form was unknown, under ordinary conditions, in the very regions in which it was at this time prevalent. As in the case of enteric fever and other diseases which have been discussed, the origin of the trouble must have arisen from a source inherent in the conditions of the campaign.

I never saw a case 'on trek,' and I never saw a case in the blockhouses, although the men engaged in these duties, particularly the former, suffered greatly from cold. The only places where I have seen it have been standing camps. The symptoms, in general terms, were those of ordinary obstructive jaundice, accompanied by irregular temperature lasting from a few days to two or three weeks. Some cases showed only transient jaundice, with slight rise of temperature. Mental depression was generally marked. Detailed information concerning clinical features can be found in Major Mathias' communication, referred to above. It was an interesting fact that during the epidemic many cases of suppression of bile, without jaundice, occurred. As these cases arose under the same circumstances as jaundice, it is possible that they were pathologically related to the latter.

As affecting the relationship of the condition to other morbid states, it must be noted that, according to Major Mathias' paper, Colonel Birt, R.A.M.C., at Pretoria did not succeed in obtaining reaction of the blood of patients with either *B. coli* or *B. paracoli*. Whatever the significance of this negative evidence may be, there is little doubt as to

the practical fact that epidemic jaundice arises under conditions of insanitary camp life. As the greatest prevalence was certainly during the coldest season of the year, it is difficult to exclude the influence of temperature. I never saw or heard of a case amongst the troops engaged in active hostilities in Natal between December, 1899, and April, 1900. An exception must, however, be made in the case of the defenders of Ladysmith, many of whom suffered severely from obstructive jaundice after the relief of the town. The trouble was generally attributed to a hasty return to a liberal diet after semi-starvation, with resulting congestion of the gastro-duodenum and bile-ducts, and occlusion of the latter. I have also seen this condition during a militia training in the West of Ireland. Many of the recruits scarcely knew the taste of meat in their own homes, and the liberal diet in barracks was rapidly followed by the above result. The disability passed off quickly without evil consequences.

The bitter cold in the Biggarsberg and Drakensberg may possibly have produced an alteration in a disease which had already been in existence for many months in the shape of the then so-called simple continued fever.*

It is well known that jaundice is rare in enteric fever, and this fact naturally weighs against a previously suggested relationship between different forms of camp ailments; but the introduction of extreme cold is a disturbing factor, and its influence could scarcely have been taken into account in estimating the usual absence of jaundice in enteric. What the exact relationship may be between enteric fever, simple continued fever, and jaundice, must, for the present, remain obscure. Certain it is that they all arise under identical conditions of camp pollution, and independently of food or water supplies, but that in the case of jaundice low temperature appears to be a favouring, if not an essential, influence. If preceding statements are correct, prevention lies in the direction of efficient camp conservancy and suitable clothing.

* Now known officially as 'Pyrexia of uncertain origin.'

CHAPTER VIII

CHOLERA

The comparative infrequency of cholera in our service has naturally deprived the study of this disease of that high interest which in former years it possessed for the medical department, as well as for the authorities as a whole.

The general causation and diffusion of the malady are wonderfully summed up in the words of the late Sir John Simon: 'The diffusion of cholera among us depends entirely upon the numberless filthy facilities which are allowed to exist, and especially in our larger towns, for the fouling of earth, air, and water; and then, secondly, for the infection of man with whatever contagion may be contained in the miscellaneous outflowings of the population. Excrement-sodden earth, excrement-reeking air, excrement-tainted water: these are for us the causes of cholera.' This general statement contains, for all practical purposes, the secret of effective prophylaxis by setting forth in vigorous and unmistakable language the essential causes of the disease. It therefore seems unnecessary to state in detail many of the precautions which medical officers should adopt in the way of prevention. These measures are well known, and clearly stated in the regulations, and are, in fact, part and parcel of the general scheme of sanitation which is now adopted as a matter of routine in the army at home or abroad. The direct connection between efficient sanitation and the disappearance of cholera is exemplified by the elimination of the disease from the army in India. Putting on one side matters

of common knowledge and common sense, there are some points in regard to prevention which are worth careful attention, among others, as will appear later, the necessity of maintaining a healthy condition of the digestive tract.

1. *The Conveyance of Infection, from the Bazaar, by Natives.* —Stress has elsewhere been laid on the possible, or it may be said probable, contamination of food by native cooks and others. When it is remembered that these men often come straight to their work, reeking with the fetor which is rarely absent from the bazaar dwelling, the danger in this direction scarcely needs further emphasis. To keep native hawkers out of cantonments and to allow equally filthy natives to prepare and handle food seems a somewhat inconsistent proceeding, if prevention of the spread of sickness from the native population is the object in view. Although, having regard to the habits of the lower class of the population, the matter presents great difficulties, the only radical procedure in this direction is to absolutely prohibit communication between the natives living in and those living outside cantonments, when cholera is prevalent.

2. *Undetected Cases in the Followers' Lines.*—Even among the natives living in regimental lines, as followers, a case of cholera may easily escape early detection, and may thus be the means of spreading the disease to British troops.

As in the case of plague, the followers' lines should be constantly watched, and here the services of a reliable native hospital assistant are invaluable. These men, thoroughly understanding, as they do, the native mode of life and native prejudices, may, in a sense, be considered the eyes of the medical department for the detection of impending danger in this direction. Cases of plague are far more likely to escape their attention than cases of cholera, as the latter present characteristics which are not so apt to be overlooked. Plague, in its early stages, may readily be confounded with some comparatively trivial ailment. It is not wise, however, to trust implicitly to partially-trained assistance. Let the hospital assistant, in cholera times, inspect the followers' lines daily, but let the regimental medical officer be present. The

hospital assistant can obtain the necessary information; the medical officer can interpret it in its true light.

3. *Spread of the Disease from apparently Healthy Persons.*—As there is reason to believe that the cholera bacillus may be passed in the excreta of apparently perfectly healthy persons, an additional reason at once becomes obvious for paying scrupulous attention to the disposal of fæcal refuse at times when cholera is prevalent.

4. *Spread of the Disease by Means of Flies.*—This danger does not appear to be as fully recognized as affecting cholera as it is in the case of enteric fever. It is a matter, however, to be gravely reckoned with. As it is impossible to effect the wholesale destruction of these insects, the best we can do is to protect, as far as possible, our food-supply from their invasion. The methods of protection are well known, and it only remains for the medical officer to see that they are rigorously enforced. Food should be served immediately it is ready for consumption. Nothing in the nature of 'scraps' should be kept. This point is worth attending to, as men occasionally put their dinners on a shelf in the barrack-room, to be eaten some time later in the day. This practice, if it exists, should be stopped at once. Fly-proof gauze in kitchens in the East is a necessity.

5. *Swimming-baths.*—It is not at all unlikely that swimming-baths may help to spread infection. A case of the kind was comparatively recently reported from India, and cholera bacilli were subsequently detected in the water of the bath. In the absence of constant care, swimming-baths very soon become horribly dirty. Unless a constant current of water can be kept flowing through them, it is doubtful, apart from chances of cholera, whether their dangers do not outweigh their advantages.

Water, uncooked fruit and vegetables, milk, and infected rags, are all known means of spreading the disease. Of prophylactic injections I have no personal knowledge. Statistics, however, go far to prove their value.

Haffkine has prepared a vaccine which he has used with good effect. He inoculated a number of labourers, and

found that among the inoculated the mortality was 2·25 per cent., among the uninoculated it was nearly 19 per cent. In another case 71 deaths took place among 654 uninoculated, and 12 deaths among 402 inoculated persons.*

The vaccine consists of an emulsion of cholera germs, of which the virulence has been increased by passage through a series of guinea-pigs. The poison is 'intracellular,' and, according to some observers, it is not only contained within the germs, but forms an integral part of the latter. A weaker vaccine, prepared from attenuated cultures of the germ, has also been used.

It is interesting to note that the living germs are injected, it being found that they are unable to multiply in the tissues of the body. The fact that the poison is intracellular, or, in other words, an endotoxin, is a point of practical importance. It is well known that the vaccine protects against the disease, and that the blood of persons inoculated is possessed of bactericidal power; but, at the same time, the blood has practically no antitoxic power—that is to say, it cannot neutralize the poison produced by the germs. It follows, as a consequence of the above, that inoculation has no effect in protecting from poisons generated by germs which may have resisted the bactericidal powers of the blood, and so established themselves in the body. Suppose, for instance, that a man is inoculated against cholera, and being subsequently exposed to infection, receives a dose of the germ with which his blood is unable to grapple—the invading germs produce toxins, but as the blood has no effective antitoxic power, the man has not a much better chance of recovery than he would have had if he had never been injected at all. It is now easy to understand the well-known fact that cholera vaccine protects from attack, but that, once the defence is broken down, the severity of the attack is not mitigated; the blood can kill germs, but it cannot neutralize the poisons which the germs produce.

To overcome this serious defect Haffkine suggests the

* Report on Inoculation against Cholera and Typhoid in the East Indies, 1900.

addition of extracellular poisons, or exotoxins, with the hope that the injected toxins will produce antitoxins in the body, just as we know to be the case in regard to diphtheria. The vaccine is stated to procure safety for about fourteen months; some observers, however, believe that it is reliable up to two years.

Greater success would probably have been attained had it not been for the fact that the germ of the disease—the *Spirillum choleræ Asiaticæ*—is not what we may call a 'fixed quantity.' For example, in 1905 Ruffer, working at El Tor, isolated from the intestines of Mohammedan pilgrims returning from Mecca a germ which corresponded almost completely with the spirillum, originally described by Koch as being the causative agent of Asiatic cholera. The pilgrims were suffering from a variety of diseases, particularly dysentery and diarrhœa; but there was no suggestion of cholera infection among them—that is to say, on clinical grounds—nor had they been exposed to such infection. Although Ruffer did not consider the germs he isolated to be the true cholera spirillum, his finding was not endorsed by Neufeld and Haendel, who, after re-examination of the germs, came to the conclusion that they were choleraic in nature.*

It has also been found by Klein that the cholera germ can retain its vitality in unsterilized sea-water for fourteen days, and from oysters which were infected by the germ in question the latter could be recovered up to nine days; he found at the same time that some of the germs had undergone remarkable changes as a result of their sojourn within the oyster, and failed to respond to all the tests necessary for the detection of Koch's germ.†

Sanarelli found in the water of the Seine and that of the Marne germs which closely resembled, morphologically, the cholera spirillum, but in which the disease-producing power

* 'Researches on the Bacteriological Diagnosis of Cholera,' Sanitary, Maritime, and Quarantine Council of Egypt, Alexandria, 1907 (*Arbeit. a. d. Kais Gesundheitsamte*, vol. xxvi., p. 536, 1907).

† Report of Medical Officer L.G.B. for 1896.

had almost disappeared. Sanarelli believed that there were modified descendants of true cholera germs, an opinion which receives considerable justification from the fact that a partial return of pathogenic power could be obtained by passage through a series of animals.*

The Danube, the Elbe, and the Rhine have also yielded germs of a nature more or less similar to the above, and as it is certain that spirilla closely resembling those associated with cholera have been found in the healthy intestinal tracts of men and animals, the presence of such germs in the rivers named is easily explained.

Metchnikoff has stated that the immunity enjoyed by animals against cholera is the result of antagonistic germs in the intestine.† It may be that the gastric juice is a still more potent defence than the above.

Macfadyen found that during fasting living spirilla administered in water to animals appeared in the dejecta, but that this was not the case when milk was made the vehicle of administration. It may be inferred, therefore, that the healthy gastric juice is able to destroy the germ of cholera, and that secretion of the juice does not take place during fasting. It is generally believed that digestive disturbance in which the quality of the gastric juice is altered predisposes to cholera.

The above facts in connection with the germ have something more than an abstract interest. If we believe that a germ closely related to that of cholera is widely distributed in nature, including the normal intestinal tract; that such a germ can undergo profound modifications in the direction of assuming or losing disease-producing power; that the gastric juice is capable of destroying this germ; and, furthermore, that the protective agent last named may become ineffectual as the result of digestive disorder, we can perceive at once the prime necessity of safeguarding troops against those factors in the shape of improper food, internal congestion, excess of alcohol, etc., all of which tend to eliminate the

* *Annals of the Pasteur Institute*, vol. vii., p. 693; vol. ix., p. 129.

† *Ibid.*, vol. vii., pp. 403, 562.

natural protection with which we are endowed. Congestion of the abdominal organs is one of the commonest causes of digestive trouble among men on service, and this congestion is, in turn, commonly dependent on external chill. To avoid the effects of chill the cholera belt is invaluable, and when it is not forthcoming a puttee wound round the body makes a very fair substitute. Men are often careless about the use of the cholera belt, and the medical officer in charge of troops in the field should not only make it his business to see that every man is supplied with these articles, but that the latter are actually worn.

From a military point of view, one of the most valuable recorded experiences of epidemic cholera is to be found in the annual report for the fiscal year ending June, 1903, of the Surgeon-General United States Army (pp. 77 and 86):

'Cholera in the Philippines, 1902, caused for the whole army an admission-rate of 6 per 1,000 of strength and a death-rate of 3·54. For the force serving in the Pacific Islands, which alone was exposed, the admission-rate was 12·84 and the death-rate 7·57 per 1,000. The total number of cases was 485 and the deaths 286, a proportion of 1 death to 1·69 cases.'

The good results of preventive measures are stated in general terms as follows:

'The success attained in protecting the lives of United States troops, surrounded as they were with the disease, was very marked. It is hardly too much to say that nearly every case of cholera in an American soldier resulted from a wilful or careless violation of standing orders, and could have been prevented had the man himself taken the trouble to carry out precautions with which he must have been thoroughly acquainted. In a small proportion of cases the disease may have been unavoidable, and even acquired while actually engaged in the work of sanitation and quarantine among the natives, but by far the larger number have been traced to unauthorized visiting of native huts or eating and drinking forbidden articles. The immunity enjoyed by troops seems to have been directly proportionate to the strictness of the

discipline maintained. Where violation of sanitary regulations was promptly followed by trial by summary court and punishment, the best results were obtained. There was, of course, some difference noted in the energy and good judgment displayed by post commanders and medical officers. Here and there occurred a failure to promptly grasp the situation, or a lack of force in grappling with it, although, as a rule, both line and staff officers worked most faithfully and efficiently.'

The full report is an exhaustive one, and it is noticeable that it contains no mention of 'pinking' the wells as a means of prophylaxis. It is recommended that all suspicious wells should be closed. Quarantine and the boiling of all drinking-water appear to have been the measures principally relied on.

Lieutenant-Colonel E. M. Pilcher, R.A.M.C., has kindly furnished me with the following account of his experience during a cholera epidemic in Lucknow in 1894. The description of what occurred is full of interest from its historic as well as from its scientific aspect:

'The following account of the cholera epidemic which attacked the 1st Battalion of the East Lancashire Regiment in Lucknow in the rainy season (July and August) of 1894 is based upon personal experience and recollection, and may possibly not be correct in minute particulars, though the main facts are as stated.

'The two British regiments in Lucknow at that time were the 18th Royal Irish and the 30th East Lancashire. The barracks are of the usual Indian pattern, two-storied, on a raised plinth and with broad verandas, and, moreover, they are arranged *en échelon*, so that one line of buildings does not shut off the prevailing wind from the next. The Royal Irish had only one or two cases, escaping practically scot-free; the East Lancashire had over 100 cases and some 90 deaths. The epidemic, in other words, was both localized and virulent. Half the regiment was in the hills at the time of the outbreak, some 400 men, including the band, remaining in Lucknow. The band escaped entirely, and the great majority of the cases came from C and F Companies.

'It is to be noted that the East Lancashire Regiment's barracks lay nearer to the Suddor bazaar than those of the Royal Irish. Cholera was raging at the time of the outbreak in the Aminabad quarter of the native city of Lucknow, at a distance of about three miles from cantonments.

'The outbreak began at the end of July during a break in the rains. On July 28 the regiment moved into camp on an open space used as a brigade parade-ground, and at no great distance from cantonments. On August 1 a move was made to Chenhut camp, a couple of miles out of cantonments across the Gumti River. That night and the next day fifty cases occurred, and some 5 inches of rain fell. After this cases were fewer, and the epidemic had practically ceased by the end of the week. The regiment returned to barracks on August 28. It was noted that the last few cases were as virulent as any of the others. As the cause of the outbreak was found to be a faulty method of water purification, it will be well to describe the system in use up to the time of the epidemic. Shallow well-water was used, and for this purpose two wells were set apart and specially protected, a complete covering of wood being built over the mouth, except where the tube of the pump used for raising the water came out. The wells were under the charge of the "sanitary corporal" of the regiment. The water was passed through a filter-bed consisting of broken brick below and sand above, and it was the practice to bake the sand at regular intervals, and also to renew the broken brick. This was last done in June. The water thus purified was passed into a storage-tank, and was then passed through Macnamara filters of the ordinary pattern, of which there was an allowance of one or two for each barrack-room.

'Subsequent investigation showed that the broken brick was probably responsible for the mischief. The medical officer in charge of the regiment had actually seen the sand heated, and there could be no doubt that it was completely sterilized. But the brick was broken up under a tree near the bazaar in the usual casual Indian fashion, and by an individual more than suspected of a mild attack of cholera. The brick, after

being broken up, was not heated or sterilized in any way so far as is known. It remains a mystery why the water thus infected should have carried an especially active cholera infection to the Macnamara filters belonging to C and F Companies, and a still greater mystery why Providence should have ordained that the filters belonging to C and F companies were taken into camp, and from camp to camp!

'It remains to mention, in connection with the water-supply, that just at this time the municipality of Lucknow had completed a scheme for the supply by means of stand-pipes to town and cantonments of Lucknow of water taken from the Gumti River above the town and filtered through sand. It was found to be bacteriologically a pure supply, and it was taken out to camp in specially purified water-carts. But it was passed through those unfortunate filters from C and F Company barracks, and consequently it was not till the clean municipal water had washed clean the infected filters that the epidemic ceased.

'The bearing of this epidemic upon the *causation of cholera from a sanitary point of view* is important, and suggests many reflections, of which the following may be mentioned:

'1. If it is too much to say that all great epidemics may be traced to an infected water-supply, this epidemic shows how sudden, how destructive, and how great an outbreak may be due to infected water.

'2. The care and supervision of matters sanitary in a regiment should be in skilled and, above all, in well-paid hands in India. The "sanitary corporal" referred to above is often a well-conducted but illiterate and ignorant old soldier, to whom a stripe has been given with a special view to shelving and rewarding him with the sanitary charge of the regimental lines. I caught such an individual defæcating in an open conduit near the regimental dairy on one occasion! A genuine interest in matters sanitary on the part of officers, the appointment of specially-instructed and paid men to look into these matters of water-supply and

sewage disposal, and then supervision, supervision, and again supervision, would have prevented this outbreak, as it will prevent others in the future.

'As regards *means of spread,* it is obvious that in this epidemic the Macnamara filters were the breeding-grounds of the microbe. Filters at that time, more than ten years ago, had not fallen under the well-merited suspicion they deserved; in fact, they were the sheet-anchors of regimental pseudo-sanitation. How, it was asked with some asperity, can the men get bad water when they have filters actually in their barrack-rooms? There is something laughable and pathetic about the question. But the answer is obvious. Water, once satisfactorily dealt with and purified, only needs a clean and sufficiently protected storage-tank.

'As regards the *prevention of outbreaks* and the *prevention of spread* during outbreaks, the following considerations present themselves:

'1. Sporadic cases cannot be prevented. They are due, as a rule, to individual carelessness. When a thirsty British Tommy shall have been educated to a sufficient degree of self-control to refuse all but safe water, we may hope to abolish cholera from the annual returns, but not till then. But the incidence of great epidemics is, as I have mentioned already, due in most cases to infected water, and prevention is a mere matter of adequate supervision. The thing is so simple that it must have been thought of before. The surprising thing is that, at any rate in my day in India, practically nothing was done. Under a fair face of whitewash unnamed horrors existed in cookhouse and latrine and washhouse. It was no man's *interest* to improve matters, and medical officers, however energetic, soon desisted from efforts at improvement defeated partly by climate, partly by good-humoured but immovable regimental inertia. A sanitary staff in every large cantonment, with special pay and special powers, trained inspectors, a proper bacteriological armamentarium, and proper encouragement and backing by the powers that be, are essential to proper sanitation in cantonments.

'2. Does going into camp help to stop an epidemic? Personally, I doubt it. Cholera camp, like the Saturday inspections, is a relic of days long past, when cholera was thought to travel with the wind, and was invested with the most capricious qualities. In our experience the cases increased by 200 or 300 per cent. when we went into camp, the reason being, of course, that we took the infected filters with us. The question is whether a regiment going into cholera camp is not likely always to carry its infection with it. Going into camp checks epidemics, it is true, but epidemics cease spontaneously in the ordinary course of things.'

Although many of the conditions referred to above have long since disappeared, nevertheless it is in the study of such experiences that medical officers will find a sure guide to the solution of problems which confront them in the discharge of the most important of their duties.

CHAPTER IX

MALTA FEVER

THE discovery by Bruce of the *Micrococcus melitensis* in 1887 and the subsequent work of Hughes placed, for the first time since the publication of a paper by Marston in 1861, our fragmentary and unsystematized knowledge of Malta fever on what promised to become a sound basis of departure in the direction of etiology, prevention, and treatment. The work of the Commission appointed by the Admiralty, the War Office, and the Civil Government of Malta, for the investigation of Malta fever, under the supervision of an advisory committee of the Royal Society, has justified the hope that our knowledge in this direction would some day be of a sufficiently complete nature to enable us to adopt means of radical prevention.

For a very definite reason the term 'Malta fever' is decidedly objectionable. It is certain that the malady is by no means peculiar to Malta.

'It undoubtedly occurs in many other places besides Malta and the Mediterranean ports. It is certainly endemic in Malta, Gibraltar, Crete, and Cyprus; probably also in Italy (southern portion), Greece, Turkey, and Sicily. There is now very good evidence that it occurs also in India, North and South Africa, Straits Settlements, and China.'*

In view of the prolonged uncertainty regarding the origin of the disease, some reference to opinions formed prior to the late finding of the Commission may prove of interest.

* Dalton.

There has always been considerable agreement among observers in attributing its origin to defective sanitation, and in the case of the Mediterranean the absence of tides would naturally aggravate conditions of this nature, by imposing a mechanical obstacle to free drainage from the land. Although many Mediterranean harbours are little better than reeking cesspools, containing every form of fœtid abomination, the continuance of the disease did not appear to depend on the growth of the germ in such surroundings. The saprophytic organisms present seemed to crowd out the *M. melitensis,* and Major W. H. Horrocks, R.A.M.C., after carefully-conducted experiments, failed to discover the form in question in the sea-water of the Grand Harbour at Malta.

Dr. Ralph Johnstone, Medical Inspector of the Local Government Board, a member of the Commission, who contributed to the work a 'Report upon the General Sanitary Circumstances of the Maltese Islands, with Special Reference to the Prevalence of Mediterranean Fever Therein,' summarized his conclusions as follows:

'Hampered by a sense of the inaccuracy of the civil notification returns, I have only attempted to draw the most general conclusions from them, except with regard to the seasonal incidence.

'The evidence I have been able to collect is not sufficient to lead to any final conclusion. . . .

'The distribution of Mediterranean fever amongst the civil population goes to show that, outside certain paved and drained areas, aggregation of persons in one locality and density of population upon area in a district favour the spread of the disease. The distribution amongst the garrison depends mainly on the age of the men and their length of service in Malta, new arrivals and young men being more frequently attacked. As regards the navy, I have only been able to obtain figures for three years. So far as they go, they tend to show that when a ship is invaded in one year, it is also invaded in each successive year, if it remain on the station.

'The incubation period seems, on the data I have been

able to collect, to be about fourteen days, but further evidence is necessary before a definite conclusion can be reached.

'As to the mode of entry of the specific infection into the human body, the facts do not permit of a definite pronouncement. The evidence, so far as it goes, seems to show that food and drink have no marked connection with the spread of the fever. Newly-turned earth falls into a like category.

'As a whole, the facts do not indicate that dust infection outside dwellings, or direct personal infection by contact, breath, or saliva, play an important part in the spread of the disease, but there is not evidence to justify the exclusion of any of these factors.

'I have been able to collect little evidence either for or against the carriage of infection by biting insects.

'The facts with regard to infection by means of excretal pollution of the hands, the food, or the dust in houses, so far as I have been able to deal with them, are suspicious, but they are not sufficiently strong to justify any conclusion.

'Some reform of the notification system in Malta is necessary before epidemiological investigation can be expected to produce the best results. In addition, facts must be collected and recorded immediately after their occurrence by competent observers. Such work cannot be adequately performed by the sanitary inspectors as at present trained in Malta.

'I have endeavoured to provide for the immediate record of a certain number of facts in relation to cases of Mediterranean fever during the year ending July 31, 1905, amongst the civil population and in the services. With regard to the former, I fear that laxity of notification will prove a stumbling-block. I regret that an urgent invitation to the Maltese medical men to forward blood samples to the public health laboratory for confirmation did not meet with the response I expected.

'I hope, however, that the facts now being recorded may prove useful in the consideration of some points.

'In the meantime, I am still in process of receiving information from Malta which I have requested, as I found

it necessary, and I should prefer to await its arrival and the consideration of the facts for the year ending July 31, 1905, before making any recommendations.' *

Dr. Johnstone's remarks on the subject of the disposal of excreta are particularly interesting as affording a general indication of sanitation among the Maltese, and they strongly suggest that the disease has its origin in filth.

'*Excrement Disposal.*—The method most generally employed is what is known as the hand-flushed water-closet. This closet is usually a long hopper basin with a siphon-trap below in connection with a cesspit or a sewer. The closet is, as a rule, used for emptying excrement and slops into. It is seldom used in any other way. It is placed in the most unexpected positions, sometimes in the open yard in a niche in the wall, frequently in the kitchen a foot or two from the cooking apparatus, or it may be in a small cupboard (1′ × 2′ usually) in the external wall of the house, or in the steps leading to the entrance-hall from the front-door, and sometimes even in the open street. It is very exceptionally found in a special room, or in a position where it is likely to be used in the usual manner. In those poorer-class houses which have got a special room for the water-closet, the room serves often also as a larder or food-store. The hand-flushing of these closets is conspicuous mainly by its absence. Water has always been a precious commodity in Malta, and is used sparingly; in addition, cesspits are emptied at the owner's expense at the high rate of 1s. 6d. per 100 gallons. The consequence is that one rarely sees a water-closet basin even moderately clean. They are usually caked with filth, and the surroundings fouled with fæcal matter. Again, when a poor proprietor owns a field or garden, he often ceases to make use of the closet in order to avoid the cost of emptying, or because he values the excrement as manure. As a result, the water in the trap evaporates, and cesspit or sewer air gains access to his premises.

* 'Report upon the General Sanitary Circumstances of the Maltese Islands, with Special Reference to the Prevalence of Mediterranean Fever Therein,' by Dr. Ralph W. Johnstone, Medical Inspector Local Government Board (pp. 60, 61).

'The next most frequent method is what may be called the misbla system. A misbla is a dung-heap, and it may be placed in the garden or yard, or more frequently in an outhouse adjoining the living-rooms, or in an ordinary room in the house. Here all the excrement of the family is carefully preserved for removal to the fields. The abominable stench that may be caused in a dwelling by this system is not easily described. Occasionally a cellar is used as a misbla, and privy-seats are placed in the room above. The vessels which are used to convey excrement from the bedrooms to its destination are often left in the house unemptied for several days. On one occasion, on asking to see the vessel used for conveying excrement to the garden, I was shown the bucket in which the vegetables for the family dinner were being washed.'*

'The relationship to temperature is proportionate.' This fact is indicated by a chart in Dr. Johnstone's report. The chart, which is well worth careful study, shows the relationship between temperature, rainfall, and number of cases amongst the civil population during the period 1894-1903.

'The curve representing rainfall is in general the inverse of that representing temperature. It attains its minimum in July, but it is almost as low in June and August. The "case" curve commences to drop at the same time that the rainfall curve commences to rise, allowing no interval for incubation and notification, so that the connection is not clear; nor does the steep rise of the rainfall curve at the end of September produce a correspondingly steep decline in the case curve, as might have been expected were the connection between the two intimate.'†

In a paper in the *R.A.M.C. Journal* for May, 1903, Captain Kennedy sets forth certain of his conclusions regarding Malta fever as follows:

'That Malta fever is not an infectious disease in the sense in which we apply the term to smallpox, scarlatina, or measles.

* Report by Dr. Ralph Johnstone, above referred to (p. 5).

† Johnstone.

'That Malta fever is a disease capable of being transmitted from person to person, probably by contagion.

'That there is a strong indication of place infection.

'That Malta fever occurs all the year round, but shows a decided preference for a certain season.

'That the Malta fever "season" begins in June, rapidly increases until it reaches its height in August, and gradually dies down in September and October.'*

Lieutenant-Colonel A. M. Davies, R.A.M.C., late Professor of Hygiene at the Army Medical College, found no evidence to justify a positive conclusion in regard to spread by means of food or water.

Although it is clear that the earlier observers seemed to make no special approach towards the present solution, their conclusions were of the highest value by eliminating uncertain factors, and so simplifying the problem which the Commission was called on to investigate; while their work, not being of a vicarious nature, belongs solely to the names with which it is associated.

It must frankly be admitted that the discovery which led to such splendid results was in some degree due to chance. Although it had been proved that dust contaminated with the *Micrococcus melitensis* was capable of imparting the disease, yet this fact could by no means account for the wide extent of infection. The possibility of biting insects being carriers of the germ was also negatived; the Commission made numerous experiments in this direction, but the results, except by a process of exclusion, did not tend to elucidation. In like manner contact was found to have no influence, although experiments on monkeys kept in close proximity to each other showed that infection was conveyed by means of the urine. It was, however, found that the disease could be imparted by inoculation, or by the mouth; and as it was clear that the latter means of infection would be far more frequent than the former, attention was drawn to the pos-

* 'Malta Fever in the Military Hospital, Valetta, Malta, during the Years 1897 to 1904,' by Captain J. Crawford Kennedy, *R.A.M.C. Journal*, May, 1905.

sibility of danger being connected with food-stuffs, and notably goat's milk.

The goat-herd in Malta is a feature of the place; he exercises his ambulatory trade in the streets, and milks his goats at the doors of his customers. Before beginning inoculation experiments, the blood of the goats was tested, and agglutination seemed to be normally present in several cases. An exhaustive investigation followed, with the result that about 50 per cent. of the Maltese goats were found to respond to the test, and that about 10 per cent. of them were excreting the germ of the disease in their milk.

About the same time that this fact came to light, confirmatory evidence was obtained by Staff-Surgeon Clayton, R.N., whose admirable work is embodied in the reports of the Commission. The evidence in question is as follows: 'An American ship, the *Joshua Nicholson*, carrying sixty-five goats from Malta to the United States, had a widely-spread outbreak of Malta fever among her officers and seamen. It appears that everyone who drank the milk of the goats developed the disease. On the termination of the voyage thirty-two goats out of the sixty that were landed (five goats died at sea) responded to the agglutination test, and several were actually excreting the micrococci in their milk' (Bruce).

Another interesting and corroborative fact is found in the final disappearance of Malta fever from Gibraltar in 1904; the cost of shipping goats from Malta to Gibraltar had considerably increased, and grazing passes had been withdrawn, so that the Maltese stock had been in process of elimination for some years, while Malta fever had correspondingly declined, until, as stated above, the disease absolutely disappeared. The results of the discovery of the part played by goat's milk in spreading infection are set forth in the Army Medical Reports for 1907.

'In the report on this station for last year it was stated that the medical history of Malta is, and always has been, the history of Malta fever. From this point of view, the garrison of the island has been happy in having, during the year 1907, no history. The number of admissions for this

disease fell to 11, as compared with 161 in 1906 and 643 in 1905. What the reduction means in actual saving to the national exchequer can hardly be overestimated. It may be briefly stated as follows: For every man in the garrison of Malta during the year 1905, the Government lost five days' pay from this cause alone. In the year 1906 they lost more than two days' pay; in the year 1907 they lost less than one-fifth of a day's pay. In a garrison whose strength is counted in thousands, this reduction is of considerable importance.

'But the loss to the nation does not consist solely in loss of efficiency or money during actual sickness; the expense of invaliding is also a serious matter. In this respect, too, there has been a gratifying decrease, the invaliding for 1907 being one-tenth that of 1906, and not much more than one-twentieth that of 1905. And even this figure is too high, since the invaliding for one year must always to a certain extent be affected by the unhealthiness of the year before. In this particular instance this effect has been very apparent, since more men were sent home for change during 1907 than actually contracted the disease during that year. We have not, therefore, benefited yet to the full extent from the improvements effected in the sanitation of Malta in respect of the incidence of Malta fever. What those improvements are it is hardly necessary to repeat. They may be summed up in a "sentence," "the prohibition of goat's milk in barracks." The reasons for this prohibition were given in last year's report, in which also the good results which have actually resulted were foreshadowed. It only remains to be said on this point that the hopes of last year have been amply fulfilled, and we can feel confident that a continuance of preventive work on the same lines will make the present fortunate state of affairs a permanent one.'*

It is now known that cow's milk can convey the disease as well as goat's milk.†

The poison of the *Micrococcus melitensis*, like that of cholera, is intracellular, which possibly accounts for the absence of

* Army Medical Report for 1907, p. 61.

† Army Medical Report for 1908, p. 52.

success attending attempts to procure an antiserum. Fleet-Surgeon Bassett Smith, R.N., whose name is prominently associated with the investigation of the disease, has used a vaccine composed of cultures killed by heat, with some success.

It is plain that a disease which is controlled with comparative ease by either boiling milk, or forbidding the use of same, does not call as urgently as enteric fever for the adoption of preventive inoculation ; on the other hand, the fact that milk is believed with good reason to be the usual cause of spread does not necessarily imply that other causes are absent, so that the ability and labour which the officer named above has brought to bear on his task must not be regarded as wasted.

CHAPTER X

BARRACK-ROOM SORE THROAT

I HAVE ventured to apply the above appellation to the lesion which is the subject of this chapter, not because I doubt for one moment that exactly the same form of throat mischief is found widely spread in civil communities, but because, to the best of my remembrance, I have observed it only in permanent barracks. There is, of course, no mystery surrounding the pathological tendencies of the British or of any other soldier, and with more extended powers of observation than those which I have enjoyed up to the present, there is, I should imagine, every probability that I should have encountered exactly the same condition in schools, workshops, factories, or, indeed, amongst any aggregation of human beings placed under surroundings resembling those which tend to arise in military life.

On three separate occasions in my service I have seen outbreaks of the kind now in question. The first was in the barracks at Warley, Essex, about twenty years ago; the second at Maryhill Barracks, Glasgow, in the early spring of 1901; the last in the South Camp at Aldershot in the winter of 1902-1903. The three outbreaks had certain definite points in common, but that at Aldershot differed somewhat from the other two in the appearances which the throats presented.

The points of resemblance were as follows:

1. That on each occasion the disease made its appearance in the cold months of the year, when many of the men sedulously guard themselves against certain hygienic measures, notably that of ventilation.

2. That the cases occurred in scattered groups in different barrack-rooms, and that the men attacked had not as a rule occupied contiguous cots.

3. That there was no epidemic sore throat amongst the civil population or amongst the married families in quarters.

4. That influenza, as far as could be ascertained, was not in existence anywhere in the neighbourhood.

Being in charge of the Isolation Hospital and District Laboratory in Aldershot, several suspicious cases were under my care, and swabs were constantly submitted to me for examination and report; but at the same time I should make it clear that my opportunities for verifying the points of origin of the mischief were not so satisfactory as in the case of Warley or that of Maryhill, and that information concerning the proximity to each other, in barrack-rooms, of men similarly affected, could only be determined by questioning the patients under my own treatment. As far as I could ascertain, by this means, immediate contiguity did not appear to act as a factor in the spread of infection. Clinically, there was a strong resemblance amongst the cases. A tough, yellowish membrane was frequently present, particularly amongst the cases that appeared at Warley and Maryhill. At Aldershot it was less common. A large number of throat cases in the last-named station showed the ordinary appearances of follicular tonsillitis, but membrane was at times present. In all three outbreaks the glands at the angle of the jaw remained apparently normal in size, or, at any rate, not enlarged to any marked extent. There was great pain in swallowing, but this, as a rule, subsided rapidly under treatment; the tongue was generally covered with fur, and the breath very fœtid; the pulse was full and frequent, and the temperature much higher than that usually observed in diphtheria. Temperatures of 104° F. and higher were commonly recorded.

In the Warley outbreak, clinical signs only were relied on for a diagnosis. At Maryhill, films were examined microscopically, but in view of the crudity of such means as were at my disposal, the results of the observations were scarcely

worth recording; but swabs submitted elsewhere for bacteriological examination invariably gave negative results. At Aldershot, although the opportunities, as already explained, for ascertaining the local distribution of the mischief were not so favourable as at Warley or Maryhill, I had, nevertheless, all necessary material for carrying out the systematic bacteriological examination of the throats. Unfortunately I have, at present, no record of the number of swabs submitted for examination; although the total must have been considerable, as doubtful cases were constantly in the Observation Ward of the Isolation Hospital. On one occasion only was the bacillus of diphtheria undoubtedly present, and this, strange to say, was in the case of a man whose clinical condition had not been such as to excite suspicion.

I remember, on the other hand, a case in which, although the throat symptoms were strongly suggestive of diphtheria, no confirmatory evidence was obtained from microscopic examination. There were certain points of difference between the symptoms noticed and those which diphtheria usually presents: the membrane was yellowish in colour and more easily separable than it generally is in genuine cases of the above-named disease; the temperature also was high, being over 104° F.; the pulse full and bounding. Looking at the case clinically, I could not satisfy myself that it was one of diphtheria, but, to be on the safe side, I administered antitoxin at once. Within twenty-four hours of the administration the man was practically convalescent, a result which, in view of the severity of the symptoms, could not possibly have been produced by any of the usual lines of treatment. Bacteriological examination failed to reveal the presence of specific forms; but as I felt considerable anxiety about the nature of the case, it was a source of satisfaction to me when the microscopic verdict, as to the absence of diphtheria bacilli, was confirmed by the report on a swab sent to a well-known London institute of preventive medicine.

The beneficial effects of the above line of treatment suggested the question to my mind as to whether morbid

throat conditions arising in epidemic form, although not containing the germ generally recognized as the bacillus of diphtheria, might not be caused by some other germ so nearly akin to the first named as to yield to a specific form of treatment. With the object of gaining information, I asked a medical officer who had had a considerable experience of isolation work if he had ever had occasion to form any views concerning this particular point, and I was interested to learn that he had based an opinion concerning the pathological relationship of undoubted diphtheria to epidemic sore throat of clinically non-specific nature on the results of antitoxin when used in cases of the last-named condition. So strong was he in this opinion that, having contracted a severe attack of what was diagnosed as tonsillitis, he had himself treated with diphtheria antitoxin, and was restored to complete health in a way which he appeared to think would have been impossible under the ordinary régime. Certain cases, under observation, in which no bacilli suggesting diphtheria could be found, were treated on the above lines with the best results. I never saw a bad symptom; the rapidity, on the contrary, with which the throat condition cleared up was most gratifying. I am well aware that this is only a very general statement, but, unfortunately, I cannot make one of a more precise nature, as I have no present access to the notes which were taken at the time, and what has gone before, in this connection, is based on memory only.

The improvement under antitoxin is, of course, only incidental evidence of the suggested relationship to diphtheria; this line of treatment is known to cause a profuse excretion from the respiratory tract, nose, and fauces, and has therefore been followed in atrophic rhinitis, asthma, etc. For information in this connection, I am indebted to the kindness of Dr. J. Odery Symes, Assistant Physician to the Bristol General Hospital.

I would here pause for a moment, and endeavour to make my position clear. I am not in the least advocating the indiscriminate administration of antitoxin in tonsillitis and the like; but, when dealing with suspicious cases,

I hold that it is contrary to common sense to wait for a bacteriological verdict which, even in the best hands, is not always justified by results, before resorting to a procedure to which no danger attaches and the value of which is fully admitted. Having made this digression, I will now endeavour to sum up the facts which have gone before.

1. We have a number of clearly localized outbreaks occurring under circumstances of defective ventilation, and, in the Warley case, of considerable overcrowding.

2. Many of the cases presented a distinct clinical resemblance to diphtheria, notably in the presence of membrane; but none of the cases that I saw answered fully to the general descriptions of that disease.

3. With one exception, the microscope failed to establish an affirmative diagnosis.

4. The cases in which specific treatment with antitoxin was employed resulted in exceptionally rapid recovery, as contrasted with others treated on non-specific lines.

The distribution of the outbreak in various rooms points, in the first place, to a diffused origin; but what the nature of the origin was can only be a matter of surmise. It is possible that it was due originally to a micro-organism of some kind which had developed virulent properties under the influence of its surroundings. The chinks between the boards of barrack-room floors tend unavoidably to become filled with dirt of all kinds, and would therefore form an excellent breeding-ground for an enormous variety of microbial forms; the energies of the latter being occasionally stimulated by the periodical scrubbing of the rooms, which process would supply the moisture necessary for vigorous growth. It is not inconceivable that the diphtheria bacillus being, under such circumstances as those just stated, protected from air and light, might have a prolonged and quiescent existence until dislodged, perhaps in a modified form, by some accidental cause, possibly the afore-mentioned scrubbing. The evidence on the whole points to a specific cause of a nature akin to that of diphtheria.

If there is any germ of truth in the above suggestion—a

suggestion which I am fully aware is not based on anything approaching conclusive evidence—it points to the practical lesson of early segregation of all cases of sore throat while the condition is prevalent amongst the men, coupled with the thorough disinfection of the quarters. The possibility of true diphtheria being developed from what is commonly regarded at present as simple sore throat should be always borne in mind. The theory of the progressive property of infectiveness is well known and widely admitted. This theory is borne out, if not conclusively, at least to a most suggestive extent, by the history of an outbreak of diphtheria on board U.S.S. *Buffalo*. At the time the outbreak occurred the *Buffalo* numbered a total ship's company of 750, of whom 450 were boys under training for seamen. The ship left the Navy Yard at Norfolk on December 4, 1902, *en route* for the West Indies. She had been lying at the Navy Yard for forty-four days, and during this time the ventilation and sanitary condition generally were, according to the published report of the medical officer, of an unsatisfactory nature. 'The latrine, some distance away, proved to be deficient in capacity and so defective that a special report was made by the surgeon of the ship, and as a temporary relief a trench was dug for the accommodation of the larger crew. During the stay at Norfolk Navy Yard thirty-eight cases of epidemic catarrh were treated. Before leaving Norfolk five cases of sore throat developed, and ten more before December 12. On December 22 two cases occurred, concerning the nature of which there was no doubt whatever; in fact, they were diphtheria of an exceptionally virulent character. The disease spread rapidly, and before it was finally mastered no less than 137 of the ship's company had been attacked.

'In the beginning of the epidemic the disease was not positively recognized, the patients being admitted to hospital with tonsillitis. The type, too, appears to have been mild until some two or three weeks had been passed, and the ship had spent some time at sea with ports closed and ventilation less efficient.'

The writer of the report appears to think that the disease

was originally of specific origin, as he says, 'There is little doubt that the disease was brought on board the *Buffalo* at Norfolk, as it has been on board the *Franklin* and *Richmond* since, and is now prevailing on board these receiving-ships.'* Whether the disease was actually imported as stated, or whether it evolved itself on board the *Buffalo*, makes no difference to the fact that the original cases were clinically tonsillitis, and developed virulent properties under the influence of defective ventilation and sanitation generally. The occurrence of the thirty-eight cases of epidemic catarrh at the Norfolk Navy Yard, before the ship put to sea, was most suggestive.

Incidentally, the report bears striking testimony to the value and safety of antitoxin. 'The serum has been used in upwards of eighty cases since the *Buffalo* arrived at Port Royal, in some cases repeatedly, without any visible ill effect or untoward accident.' There were 'two deaths out of 137 cases, and not a single death after the antitoxin treatment had begun.' The serum was also used as a prophylactic, apparently with satisfactory results. The whole report is well worth study in its original form. It would be interesting to know if the Hofmann bacillus was discovered in any of the throats; but to prosecute a search of the kind at sea would have been most difficult, if not impossible. I never succeeded in detecting this bacillus with certainty; this I feel to be a matter of regret, as any light whatever thrown upon this form in its connection with throat affections, diphtheritic or otherwise, is worth recording. As affecting the significance of the last-named bacillus, the report for 1903 of Dr. Davies, Medical Officer of Health for Bristol, will repay careful perusal. The following extract from the *British Medical Journal* for September 10, 1904, which refers both to Dr. Davies' able report and also to the work of Professor Stanley Kent, contains, in this connection, much suggestive material:

* 'Report of an Epidemic of Diphtheria on Board U.S.S. *Buffalo*,' by G. E. H. Harmon, M.D., Medical Inspector, United States Navy (*Journal Association Military Surgeons U.S.A.*, 1904, p. 94).

'Dr. Davies' conclusions as to the part played by the pseudo-diphtheria bacillus of Hofmann are not in entire accord with the recently expressed view of Dr. Thomas and others as a result of experience in the Metropolis. The Bristol experience points to the view that the presence of the Hofmann bacillus amongst children who have been in direct association with cases of clinical diphtheria is a sign of danger, as "their frequent appearance in both stages of throat diphtheria, and their constant occurrence amongst contacts with clinical diphtheria (especially in schools), leads us to attach serious importance to them when found in intimate association with an outbreak of recognized diphtheria, and to ascribe to them in such association the rôle common to the mildest forms of scarlet fever or of small-pox—that is, of keeping alive an infection which, if marked clinical cases alone occurred, might readily be blotted out."

'This is a clearly-defined position, and, on the whole, we are of opinion that the occurrence of the Hofmann bacillus must for the present be viewed with suspicion.

'Professor Stanley Kent, who had undertaken the bacteriological examinations at Bristol in 1903, reports that of 5,545 examinations made for the Klebs-Löffler bacillus, 768 cases showed the specific organism to be present in free growth, 465 in scanty growth; 1,404 revealed the pseudo forms, including Hofmann.

'Professor Kent concludes that evidence is accumulating to prove "that the Hofmann bacillus may, under certain conditions, produce a disease undistinguishable from ordinary diphtheria produced by the Klebs-Löffler organism."'*

Although microscopic examination of swabs threw no definite light on the nature of the cases, under my care, which have been discussed, I nevertheless observed that there was a certain ratio between the number of streptococcal forms and the severity of the attack. Whether antistreptococcal serum would be useful when antitoxin fails is a question worth considering. In one case in which pyæmic symptoms manifested themselves I administered antistreptococcal serum

* *British Medical Journal*, September 10, 1904, pp. 625, 626.

with very satisfactory results. The case, which was one of fœtid sore throat occurring as a sequela of scarlet fever, had resisted all other modes of treatment, and was in imminent danger of dying at the time this measure was adopted. I much regret now that I did not begin it sooner, as, although the patient recovered perfectly, his illness might have been materially curtailed.

Sore throat is rather apt to find itself thrust away into the unclassified residuum, but it nevertheless offers a wide field of practical research to those who have the necessary material at hand. I should add that the remarks contained in this chapter, taken as a whole, are only intended to be suggestive of a branch of professional work which promises results of equal practical value and scientific interest.

CHAPTER XI

ANIMAL PARASITES*

THE animal parasites which affect human beings can be conveniently divided, with the object of practical classification, into internal and external. The presence of the former in drinking-water is a matter of common knowledge, and for all purposes of ordinary utility this may be considered the principal means by which their entry into man is brought about. It would be an act of uncalled-for repetition to enter into details concerning the developmental phases of these forms of life. The facts in question are doubtless of extreme interest from the point of view of abstract science, but knowledge of this kind is of no particular value for the practical routine of everyday life, and if desired can be found in its proper place. There are, however, certain other facts which, without going into minute details, are worthy of the careful attention of medical and other officers, and which may possibly be overlooked in the multiplicity of questions bearing on the health of troops, which call constantly for consideration, particularly during service in the field.

One of the most important of the internal parasites, from a military point of view, is the *Bilharzia hæmatobia*. The developmental stages consist of the ova, the larvæ, and the fully-formed parasites. The larva is believed to become encysted in some minute fresh-water host, and in this form infection commonly occurs. Drinking-water furnishes the usual means by which access is gained to the body. The

* Strictly speaking, malaria should be placed under this heading, but as a matter of convenience it is considered elsewhere.

practical as well as the scientific interest of this fact is evident. Many men were affected in South Africa during the recent war. It has often been stated that infection may occur through the anus or urethra, during bathing. Personally, I doubt if bathing is dangerous, unless water is accidentally swallowed. The initial symptoms may be so slight as to escape detection; they commonly consist in the presence of a small quantity of blood in the urine. The quantity may increase later on to a serious extent. The absence of pain and the trifling extent of the hæmaturia often cause the disease to pass unnoticed in its earlier stages. In my own experience, hæmaturia of varying severity has been the only manifest symptom, although I must admit that the number of cases I have seen has been limited. As the case progresses vesical irritability is stated to occur, and may be accompanied with great pain. The parasite may also be found in the lower part of the alimentary canal, and its presence here is likely to simulate malignant disease. The ova are passed in the excreta, and can readily be detected under the microscope; their appearance is now a matter of common knowledge, and the methods of obtaining them for microscopic examination are perfectly simple. A drop of urine containing the sediment is taken up with a pipette and spread in a thin layer on a slide; a $\frac{1}{6}$-inch lens should be used; the ova, when in the field, are detected without the least difficulty.

One point of eminently practical importance must always be kept in view — namely, that unless the excreta are sterilized the disease may spread indefinitely. In the issue for March, 1904, of the *Journal of the R.A.M.C.*, Captain C. R. Lewis, R.A.M.C., and Captain E. P. Sewell, R.A.M.C., each report the occurrence of this disease in India. In the case reported by Captain Sewell the man had only served in England and India, and it does not seem unlikely that the disease was contracted in India from a case imported from South Africa. Both of the above-named officers call attention to the possible spread of this disease from South Africa as a centre. The foregoing danger does not appear to have received quite the attention which its importance

deserves, and Captains Lewis and Sewell have done valuable work in publishing their experience.

In view of existing knowledge, it is manifest that men suffering, or suspected to be suffering, from this disability should be subjected to the same precautions which are adopted in the case of enteric patients, as far as the sterilization of excreta by heat is concerned. It would be a step in the right direction if non-commissioned officers and men were instructed concerning the practical aspects of the disease. Its importation to India and the colonies is far from a visionary danger, and by the dissemination of the necessary knowledge it may be possible to ward off the advent of a serious disability into those of our possessions in which this parasite has, as far as we are aware, been, up to the present, unknown; there is good evidence that it is mainly limited to South Africa and Egypt, and the prevention of its further spread may well invite the attention not only of the military, but also of civil members of the profession, and particularly, amongst the latter, of medical officers of health. It is true that the geographical distribution and life-history of the worm have not been fully worked out, but the absence of knowledge, in this direction, need be no barrier to the adoption of reasonable methods of precaution. It is always better to assume the existence, rather than the absence, of a possible danger. I remember that the first case I ever saw, which happened to be at a home station, was the cause of considerable speculation as to the nature of the lesion, but all doubts were finally set at rest by the discovery of the ova in the urine. In the meantime the patient, who had been marked 'up,' and who, except for the occasional passage of blood, was quite in a condition to give full play to his physical gifts, passed water, with some reservations, exactly where he thought fit—a freedom of choice which included a field bordering on the hospital, where, there was reason to believe, certain patients surreptitiously betook themselves after sundown, for purposes unconnected with the present subject. This field being bounded on one side by a stream, the dissemination of the ova by water was quite within the bounds of possibility.

In country districts dangers of this kind may very readily arise, a fact which has been pointed out by Captain Lewis in the report mentioned, and the above case has been introduced with the object of affording a possible illustration of the force of that officer's warning, Dr. Alliott, of Sevenoaks, has also reported cases which certainly appear to have originated in South Africa. In India, where the tanks swarm with all sorts of aquatic forms of life, the disease would certainly find every facility for rapid dissemination. The indications for prevention are sufficiently well known, and have been indicated above. The present is without doubt the time to put them into action.

Ankylostoma Duodenale.

This parasite, which is found, as its name implies, in the upper part of the intestinal tract, has not, on the whole, received the attention which, it is to be hoped, will now be bestowed on the *Bilharzia hæmatobia;* but the possibility of its occurrence, particularly in view of its very widely-spread distribution, should never be forgotten on service, or on peace manœuvres. It is a fact of great practical consequence that the ova and not the developed parasites are passed by the host. The larvæ are hatched only after the ova have left the body, and although all details of their life-history are not yet fully known, it is generally believed that they easily maintain their vitality in water, damp earth, or mud, particularly if freely exposed to the air. Oxygen appears to be essential to their existence, so that complete immersion would probably destroy them. The ova can also, if not completely immersed, exist in water, notably in muddy water. It is during the larval stage that infection is believed to occur. Attacks are common among persons who are engaged in digging or tunnelling operations. It is a matter of history that the operatives engaged in boring the St. Gothard Tunnel were most seriously affected by the attacks of this parasite. The disease has acquired an interest in this country owing to a comparatively recent outbreak in Cornwall.*

* Report to Home Secretary on an outbreak of ankylostomiasis in a Cornish mine, 1903 (Haldane).

It is generally believed that outside the human body the development of the parasite never goes farther than the larval stage, but this view has been combated by Dr. A. T. Ozzard, who has brought forward evidence tending to prove that sexually mature forms may come into existence in the free state.*

The precautions which should be adopted are fairly evident —viz., the purification of drinking-water and the avoidance of eating with unclean hands, or placing food on the ground. On service, ordinary acts of cleanliness are constantly disregarded. It cannot by any possibility be otherwise. Like everything else, sanitary measures can be overdone, but in this case the danger is sufficiently great to place certain precautions outside the realm of absurdities. It should be a standing order that men on service should wash their hands before eating, whenever it is possible to do so. The danger of conveying food to the mouth with soiled hands is by no means limited to the chance of attack by the parasite at present in question. The risk is of a widely-spread character, but has a special application in connection with field service. According to the researches of Professor Looss and Dr. Schaudinn, the parasite may effect an entrance into the body through the unbroken skin.

'A few years ago a well-known helminthologist, Professor Looss, gave expression to the opinion that ingestion by the mouth was not the only way in which the larvæ of *Ankylostoma duodenale* might gain access to the intestine, the alternative portal of entry being the skin. This view did not meet with general acceptance. The theory of Professor Looss has, however, been considered of sufficient importance to call for an independent investigation which has been undertaken by Dr. Fritz Schaudinn, of the German Imperial Board of Health. Dr. Schaudinn now publishes a preliminary communication on the results he has so far obtained. His experiments have been performed on young monkeys, proved,

* 'Life-History of *Ankylostoma Duodenale*,' by A. T. Ozzard, M.R.C.S., Government Medical Officer, British Guiana (*British Medical Journal* September 18, 1909).

by repeated examinations of their fæces, to be free from the parasites. Over a small patch between their shoulder-blades the hair was cut close, and 5 or 6 drops of a watery suspension of ankylostoma larvæ were spread on the skin. During this procedure the monkey was held in position by an attendant, and was not released until all the fluid had dried and the bare patch of skin and its surroundings had been thoroughly washed with absolute alcohol. The first experiment was made on May 28. The animal died on June 10, and in the upper third of the small intestine thirty-six living ankylostomata were found. The stage of development in all was from the tenth to twelfth day. A second monkey was infected in the same way on three successive occasions—namely, 11th, 29th, and 30th of June—and it was killed and examined six hours after the last infection. Worms were found in the intestine and numerous larvæ in the skin; of the latter, some were in the hair follicles and some in the corium. Dr. Schaudinn now finds himself in a position to confirm the observations previously made by Professor Looss.' *

This source of danger illustrates one of the possibilities of indiscriminate bathing, although, at present, it would be practically impossible, in the vast majority of cases, to take any really preventive steps in this direction.

It is believed that the worms can live for some years in the human intestine, and it is therefore exceedingly difficult to frame adequate precautions against such an obvious danger. The sterilization of the stools of sufferers presents itself as a sound measure, as far as it is applicable.

The presence of the parasite is associated with a high degree of anæmia, to which may be added swelling of the feet, pleural and peritoneal effusions, digestive derangements, and, occasionally, fatty degeneration of the heart and fatal syncope.

It is now believed that the symptoms are probably due to some toxin formed by the parasite and absorbed by the hosts. The toxin is supposed to destroy the red corpuscles of the

* *British Medical Journal*, October 1, 1904, p. 852.

blood. If this belief is true the existence of anæmia is easily accounted for.

Rhabdonema Intestinale.

This worm is commonly associated with the preceding, but a practical point of difference between the two is found in the fact that in the latter the embryos are developed before leaving the body. They are stated to have a short existence, unless they reach water. The worms are believed to have been the cause of a serious form of diarrhœa which occurred amongst the French troops in Cochin China. It is, however, doubtful whether this organism actually possesses the pathological importance which was at one time assigned to it.

Dracunculus Medinensis.

The larvæ of the parasite exist within the body of a small fresh-water crustacean, which latter, fortunately, appears to have only a limited distribution within the countries in which it is found.

It is stated to be unknown in Europe, but exists in parts of Egypt and India, the West Coast of Africa, and the West Indies.

Distomum Ringerii.

This, like the foregoing, is aquatic in origin. It appears to be common in parts of Japan, and gives rise to symptoms which may be mistaken for those of pulmonary consumption.

Filaria Sanguinis Hominis.

The presence of this parasite is one of the dangers associated with impure water. The water is believed to become infected by the transference to it of larvæ from the blood of man. This transference is held to be carried out by mosquitoes. Chyluria and elephantiasis are each attributed to the existence of the parasite in the body.

Fragments of tapeworms and their eggs may be found in water. One of the forms by which man is likely to be attacked is the *Tænia echinococcus*, the ova of which are well known to develop into the hydatid cysts which are found in the liver and elsewhere. Infection may occur through eating watercress or certain other raw vegetables.

In meat other fairly common forms may be present—namely, the *T. solium* and the *T. mediocanellata*. The former attacks pigs and gives rise to measly pork. The latter is found in the ox; it is commonest in calves, and is spoken of as 'beef measles.' The appearances presented are described in works on food inspection, but no written account can replace knowledge gained by the actual senses.

The *Trichina spiralis* is a dangerous parasite which is found in the pig. It is enclosed in an ovoid capsule, and its seat is in the muscles of the animal. The presence of the capsule is a fact to be remembered, as it protects the parasite during the process of cooking. A temperature of 150° F. is necessary for the destruction of the worm, and as this degree of heat cannot be assured under conditions of service, pork should not be issued to troops in the field.

The above by no means exhausts the list of known internal parasites, but it comprises those by which the soldier, on service or at home, is most likely to be attacked.

What the respective effects of the chemical procedures which have been suggested for the purpose of water sterilization would be on any or either of the above forms can only be a matter of speculation—a fact that in itself furnishes a sufficient reason for pinning faith on either heat or filtration, as the former destroys and the latter removes practically all forms of life which give to water dangerous potentialities. The water in the South African spruits and rivers was absolutely swarming with animalculæ, and yet it is proposed to resort to measures, in the direction of chemical purification, which, as far as we know at present, would leave such forms of life untouched, but would act as problematical safeguards against problematical dangers. To assume the existence of the *B. typhosus* in a stream flowing through an uninhabited region is to assume what is improbable, but to assume the possible existence of animal parasitic forms is a very different matter, and it is therefore more reasonable to take steps which will insure safety against both sources of danger rather than steps which only insure against that which is the least likely to be present.

SLEEPING SICKNESS.

The blood parasites connected with sleeping sickness have recently attracted widespread attention. For knowledge gained in this direction the profession is indebted to the original discoverer, Dr. Castellani, and to the subsequent combined researches of Colonel Sir David Bruce, F.R.S., Captain E. D. W. Greig, I.M.S., Dr. Nabarro, and others.

The disease shows itself by gradually increasing lethargy, pyrexia, and tremors; it runs a more or less chronic course, to a fatal ending.

Sleeping sickness has been known in different parts of Equatorial Africa since the early part of the last century, but the actual cause of the disease in the shape of a protozoon, which has received the name of *Trypanosoma Gambiense*, was unknown until 1902, when the organism in question was discovered by Castellani as existing in the cerebro-spinal fluid of affected persons. The size of the organism is about 22μ by 2μ; it is furnished with a longitudinal undulating membrane, and terminates anteriorly in a free flagellum; the general appearance rather suggests a speck of living jelly. Colonel—now Sir David—Bruce arrived in Uganda on March 16 of the above year (this date being subsequent to Castellani's discovery), and the work carried out by the Commission of which he was the head established the connection between the organism named and the disease under investigation.

The trypanosome can be found in large numbers in the cervical glands, the latter being commonly enlarged, and when cerebral symptoms appear it also will be found in the cerebro-spinal fluid, but in the last-named situation the numbers are not as great as in the former. It also exists, in small numbers, in the blood.

The disease is conveyed by a tsetse fly, the *Glossina palpalis*. It appears that the insect acts by carrying the infective organism on its proboscis, as there is evidence to show that if the proboscis has been wiped free of the organism by passage through the skin of a victim, a second person

attacked is not affected. It does not seem likely, however, that the disease is exclusively spread by mechanical means, as a fly in which the mid-gut 'was absolutely crammed with active, seething masses of these flagellates' was recently dissected by Captain F. P. Mackie, I.M.S., while the salivary glands contained 'large numbers of altered-looking trypanosomes.' *

The fly belongs to the same order as the common house-fly. The proboscis is long and straight, and the wings fold entirely over each other. The female does not lay eggs, but produces a full-grown larva; the larva is yellow in colour; after birth it secretes itself in a hole in the ground, when it shortly changes into a hard dark-coloured pupa.

It is clear that the prevention of the spread of the disease is a question of great difficulty. The establishment of medical inspection ports has been suggested, so as to prevent infected persons from entering non-infected areas where the means of the disease conveyance in the shape of *Glossina palpalis* is present.

Enlargement of the cervical glands is very common among negroes. I have noticed enlargement of this kind was frequent among men of the 1st West India Regiment in Barbados, and I was very puzzled as to its cause. The battalion had been recently serving in West Africa, and it is therefore possible that some of the men may actually have been carriers of the disease. *Glossina palpalis* is unknown in Barbados—or it certainly was so at the time of which I speak—or the consequences might have been disastrous.

Other protozoa which, in their incidence among equines, may have an influence, although an indirect one, on the health of troops are *Trypanosoma Brucei* and *Trypanosoma Evansi*. The former is the cause of nagana, a disease which attacks horses, mules, and donkeys; it is found in Zululand and West Africa. The disease is very fatal: the symptoms

* 'The Development of *Trypanosoma Gambiense* in *Glossina palpalis*,' by Colonel Sir David Bruce, C.B., F.R.S., Captain A. E. Hamerton, D.S.O., Captain H. R. Bateman, R.A.M.C., and Captain F. P. Mackie, I.M.S. (*Journal of the R.A.M.C.*, February, 1910).

are swelling of the legs and of the neck, discharge from the nostrils and eyes, and fever. *Trypanosoma Evansi* is the cause of surra, a disease which also attacks equines; it is found in Burma, Mauritius, and the Philippines. Koch and other observers consider that the two above-named diseases are identical. It is certain that the first named is spread by a biting insect—viz., a tsetse fly, the *Glossina morsitans;* it appears probable that the latter disease is spread by somewhat similar means in the form of the *Stomoxys* or *Tabanus.* It is stated that of the two trypanosomes, the *Trypanosoma Evansi* is the more active in its movements.

KALA-AZAR.

This disease is common in Assam, and is also found in parts of India; it is characterized by anæmia, splenic enlargement, dropsy, and a tendency to hæmorrhages. Like the diseases which have just been discussed, the condition is caused by Protozoal invasion, the parasites in question being known as the Leishman-Donovan bodies. These are small, round, ovoid bodies, which seem to be encapsuled and contain two masses of chromatin; one of these masses is large and oval, and the other one is small and rod-like. The large mass stains pale red and the small mass deep red with Leishman's stain. Leishman believes that these bodies are degenerate trypanosomes.

In spite of what has been stated as regards the identity of these bodies and those found in Delhi boil, the cause of the latter disease is quite different from that of kala-azar.

There is good evidence in favour of the theory of spread by means of a blood-sucking insect, and, according to Rogers and Patton, suspicion points strongly to the Indian bed-bug, although negative evidence opposed to the above is found in the comparative rarity of the parasite in the peripheral blood.

Although the pathology of the disease has mainly been elucidated by the splendid work of Leishman and Donovan, the knowledge which we now possess of the subject as a whole is due to the labours of many, notably Christophers, Bentley, Patton, and Rogers.

In view of recently discovered facts, it seems likely that many cases of so-called 'pyrexia of uncertain origin' may be due to some infective agency conveyed by the *Phlebotomus Papatassii.* In connection with this question, the Army Medical Report for 1908, regarding the health of troops in Malta, is most suggestive.

'There were 303 admissions under the heading of 'pyrexia of uncertain origin,' a number which, though high, is low as compared with the admissions in former years. The blood of all these cases had been carefully examined, and enteric fever, paratyphoid fever, and Malta fever carefully excluded. These cases occur mostly in the summer months, when sand-flies and mosquitoes are most troublesome, and it is suspected that these insects may possibly be concerned in the transmission of the disease. In this connection reference may be made to the existence in Herzegovina of a disease much resembling the ordinary cases shown under this heading, which has been proved were spread by the *Phlebotomus Papatassii.* An investigation into this point is at present under progress, an officer of the Royal Army Medical Corps having been specially sent to Malta for this purpose. It may be remarked that sand-flies belonging to the same genus as the disease-spreading fly of Herzegovina are very prevalent in Malta during the summer months from April to September; these insects enter into the barracks and quarters at night in great numbers, their bite is acutely painful, interfering very much with the men's rest, and not infrequently being followed by a cellulitis, which renders men unfit for duty for some time.*

Lieutenant-Colonel C. Birt, who has recently carried out a most painstaking and able inquiry, finds that the blood of a person suffering from Phlebotomus Fever is virulent during the first day, and that the virus can pass through a Pasteur-Chamberland candle. No organism has yet been detected. The resemblance to dengue is obvious.†

* Army Medical Report for 1908, p. 53.

† 'Phlebotomus Fever in Malta and Crete,' by Lieutenant-Colonel C. Birt (*Journal of the R.A.M.C.*, March, 1910).

External Parasites.

External parasites, notably those connected with itch, are common enough in peace-time, and during war their presence may become a most serious factor in the production of sickness amongst the men. A letter, in this connection, of the late Sir Thomas Longmore is well worth quoting *in extenso.*

'Camp above Sebastopol,
'*March* 29, 1855.

'My dear Birkett,

'I received your letter of the 9th inst. to-day. I write a hasty line to let you know that I have sent you two packages of the veritable Crimean pediculi. I don't know whether they will survive the voyage, but perhaps they may, and they may then be of some interest, perhaps, as evidence before Mr. Roebuck's committee. They are not likely to multiply and spread among you clean people in London, as they seem especially engendered by dirt and neglect. They infest the woollen clothes first, afterwards the person, and have no particular fondness for those parts of the body covered with hair. (When a man has had the head, etc., infested with vermin, as well as the clothes, the lice have been distinct in species.)

'The lice so much talked about in the Crimea are of the same family, I believe, as those which infested our troops in the Peninsula—at least, an old Peninsular officer told me so. The pediculi I send you were as common, and seemed to thrive nearly as well on the ground for some time as on the clothes, and the officers, who had to lie down in the trenches where also the men were in the habit of lying, got them in this way in considerable numbers every time they went on duty in the trenches. They multiplied with marvellous rapidity in the clothes and persons of men who became anæmiated and much debilitated, and the increase of vermin and increase of debility, by mutual co-action, went on at last at geometrical ratio until death carried off the man. Putting out flannels for a couple of days in snow destroyed the lice, but not the ova, and it was very difficult to get rid of them, as we had no means of boiling or baking the clothes. The

larger lice burst from the effect of the cold when placed in snow; others became shrivelled up.

'Here is an epistle on rather a curious subject, and you should have witnessed the surprise of a military friend of mine who took up one of the small parcels directed to you when I announced to him the contents.

'The pediculi when packed up were alive and seemingly thriving, they are still tenants of their native flannel, and are stowed away, not so tightly as to interfere with their comfort, in two empty match-boxes. To obviate any chance of escape, I have carefully pasted them up with a covering of white paper, more particularly out of consideration to Watt, who is the bearer of them to you.

'Believe me,

'Very truly yours,

(Signed) 'THOMAS LONGMORE.'*

On board ship itch is a very serious matter, as once it is established in the mess-decks it is very difficult to eradicate it. The safest plan is not only to pass the blankets, etc., of the infected man through the disinfector, but to carry out this procedure in regard to the same articles belonging to the other men of the mess. The blankets should be sent for at once, before they get mixed with others. The remainder of the men in the mess should be paraded at once and thoroughly examined, and the examination should be repeated daily for a few days.

The extent to which disease may spread by vermin is unknown, but when it is remembered that these parasites comprise forms which gorge themselves with blood and with certain of the exudations which the absence of cleanliness leaves upon the most unsavoury portions of the human frame, and when it is further remembered that within the crowded and fœtid precincts of a tent the transference of the parasites from man to man can scarcely fail to take place as a constant occurrence, we can readily accept the probability of the conveyance of a variety of morbid conditions by these exceptionally disgusting means.

* *Journal R.A.M.C.*, March, 1904, p. 363.

On service a constant watch should be kept for the advent of this source of trouble, and non-commissioned officers and men should be instructed as to the danger of not immediately reporting sick when infected. The quickest way to get rid of these pests is to strip the affected person or persons absolutely naked; hair should be shaved off with a razor, and paraffin liberally applied, followed by the vigorous use of soap and water. The clothing should be steeped in boiling water. Other methods are uncertain, as the ova are likely to escape. In certain cases these measures may naturally be modified, but as a general rule they should be applied in their entirety. Tents in which cases have occurred must be removed, and boiling water poured over their former positions; the canvas should be well scrubbed with hot water and soap, and the application of some antiseptic should follow.

Fleas are often found in the joints of iron bed-cots. The frames should be unjointed, and the various parts heated for a few seconds in a fire, or plunged into boiling water.

At St. Helena the fleas in the bed-cots were a most serious annoyance. Paraffin was recommended as an insecticide; but its use was not followed by any exceptional results, probably because it was not brought into sufficiently intimate contact with the forms it was meant to destroy. Vermin are occasionally to be found in the crevices of plank beds, and also in the iron framework which supports these beds. The boards should be constantly removed and boiling water applied, and they should be then scrubbed in the ordinary way. Any ova or vermin present in the iron framework may be destroyed by the rapid application of a flame. Fleas and other vermin interfere with natural repose, and are thus likely to be a source of ill-health. In the words of a late distinguished general officer, 'Fleas allow no rest, and should be allowed none.'

Although the subject of vermin is in itself singularly unattractive, its possibilities, and therefore its importance, should relieve it of some part of its natural repulsiveness.*

* For an admirable account of certain parasites as affecting military efficiency, see papers by Major F. Smith, D.S.O., R.A.M.C., which appeared in the issues of the *R.A.M.C. Journal* for February and March, 1905.

CHAPTER XII

SANITARY ORGANIZATION

In its true sense effective sanitary organization in the army means the practical application of sanitary principles to every detail which has any bearing on the physical efficiency of the soldier. In fact, sanitary organization is something considerably wider than the designation and distribution of certain units charged with conservancy functions. Of course it is not meant to imply that the existing sanitary organization has limitations of this kind, but it is quite an open question as to whether full advantage is always taken of the special knowledge and training available in connection with schemes in which the health of troops is intimately concerned. It is not, in fact, stepping beyond the limits of accuracy to state that there is often a greater tendency to obtain skilled opinion in regard to completed rather than to projected schemes, and it may reasonably be assumed that pecuniary expenditure and official friction might often be avoided if the appointed experts were consulted with regard to proposals affecting their special branch—from the plans of barracks to the manufacture of new boots and stockings. It need scarcely be stated that expert opinion partakes of the nature of advice only, and, as an adviser, the sanitary expert has neither legislative nor executive functions. Once advice is tendered, responsibility for action does not rest on his shoulders. To endow the adviser with the power of enforcing the practical expression of his opinion would not only be destructive of discipline and derogatory to the authority

of commanding officers, but would quickly end in official chaos.

In the case of sanitary procedures which are defined by legislation, and for the performance of which special units have been formed, another principle obtains, and a medical officer is armed with executive functions to insure the satisfactory performance of the legislative scheme.

In peace-time sanitary organization principally consists in the inspection of barracks and camps, the selection of military locations, and the framing of recommendations in accordance with facts observed; in addition to the above, reference is made to the medical authorities with regard to a variety of questions, such as issues of clothing, hospital supplies, etc., and the scheme, of course, comprises the ordinary work of a public health laboratory.

Although, no doubt, the above, in actual practice, covers a fairly comprehensive field, and although there is no ground for suggesting that expert advice is minimized or in the least underrated, it is at the same time undeniable that such advice is not invariably obtained in the initial stages of schemes involving questions of sanitary administration. This limitation is by no means peculiar to our own service, and in this connection the views of the Surgeon-General U.S. Army are worth quoting:

'In addition to the granting of executive authority to the Medical Department in sanitary matters, all the special apparatus used in sanitary work and the care and transportation of the sick, such as ambulances, water-carts, water-sterilizers, disinfecting apparatus, field crematories, etc., should be purchased and supplied by the Medical Department. This would have the effect of putting into the hands of the sanitary expert the means necessary for carrying into effect his recommendations, so that they may be employed at such times and in such manner as his special knowledge and experience may dictate, and would definitely fix the responsibility for sanitary measures. The efficiency of these special appliances usually depends upon the details of their

construction—details with which only a specialist can be expected to be familiar; and still more important is it that he should be able to control the time, place, and quantity of issue of such appliances.

'In paragraph 1405, Army Regulations, "the Medical Department is charged with the duty of investigating the sanitary condition of the army and making recommendations in reference thereto. . . ." And in paragraph 1406 it is stated that "the surgeon, under the direction of the commanding officer, will supervise the hygiene of the post or command, and recommend such measures as he may deem necessary to prevent or diminish disease. He will examine at least once a month, and note in the medical history of the post, the sanitary condition of all public buildings, the drainage, the sewerage, amount and quality of the water-supply, the clothing and habits of the men, and the character and cooking of the food; and immediately after such examination will report thereon in writing to the commanding officer, with such recommendations as he may deem proper."

'As the regulations now stand, defective sanitary arrangements in construction work do not come to the notice of the sanitary department of the army until the work is completed, and mistakes which might easily have been prevented at the proper time may have to be corrected at great expense and loss of time, or they are not corrected at all, and avoidable sickness results. It is therefore recommended that the regulations be so amended as to provide that, except in emergency, no buildings for occupation of troops shall be constructed or altered until the opinion of the proper officer of the Medical Department has been obtained as to the sanitary questions involved in construction, arrangement, plumbing, heating, lighting, ventilation, etc.; nor, except in cases of emergency, shall any existing buildings not already occupied by troops be used for such purposes until an opinion has been obtained from the Medical Department as to their suitability from a sanitary point of view.'*

* Report of Surgeon-General United States Army for 1907, pp. 38, 39.

Considering the appreciative spirit in which sanitary advice is received, a further expansion in the direction indicated would probably not only be unopposed, but heartily welcomed. In war the sanitary personnel, exclusive of men told off for water-duty, consists of one sanitary officer to each division ; a sanitary officer to each district on the lines of communication, and a sanitary officer at the base, who is also port sanitary officer ; a sanitary section, R.A.M.C., consisting of one officer, four non-commissioned officers, twenty privates, and one batman to each base, to each district, and to each rail-head; a sanitary squad, R.A.M.C., consisting of one sergeant and five privates to each post or railway post on a line of communication; two sanitary squads for each advanced base; and sanitary squads in the proportion of one non-commissioned officer and eight men per battalion, brigade of artillery, or regiment, for duty with units in the field. In addition to the above, a Sanitary Inspection Committee will be formed on mobilization for war. This Committee will have a combatant officer as president, and a field-officer R.E. and a field-officer R.A.M.C. as members. The actual duties of the Committee are laid down in Army Order No. 3, 1908. In general terms the Committee will be responsible for the due supply of all sanitary appliances, for the initiation of sanitary schemes, and for the supervision of sanitary work, both military and civil.*

In May, 1908, a sanitary section was mobilized in camp at Strensall. The strength was about 3,000 of all ranks. The unit assembled on May 18, and demobilized on July 21. The result was gratifying, and clearly demonstrated the value of sanitary organization.†

The work of the organized units will, in the very nature of things, be mainly concerned with questions of water-supply and conservancy generally. In standing camps good results may reasonably be expected to accrue; but once troops are moving many sanitary precautions are thrown to the winds.

* Army Medical Report for 1908, p. 38.

† For further details see chap. x., part ii., 'Field Service Regulations.'

It is under such conditions of activity that the advice of the medical officers attached to divisional headquarters may prove invaluable. Transport has often to be cut down to the 'irreducible minimum,' and it is within the province of the sanitary adviser to state his opinion as to what the 'irreducible minimum' had best comprise. To give such advice effectually a knowledge of the general scheme of operations is necessary, and therefore to facilitate the above it would be well if the Principal Medical Officer of the Division were included in the staff of the General Officer Commanding. It is possible that advice tendered may be incompatible with the ready attainment of the objective. Whether this is the case does not concern the adviser; it rests solely with the actual head of the force to decide whether he can or cannot adopt the suggested measures. The actual advice to be given could be settled by consultation with the Divisional Sanitary Officer. In short, to make sanitary organization in the field a success, the appointed adviser should be in a position to adapt his advice to the exigencies of the situation. When sanitary details have been determined, and their nature made public in orders, the medical service, as represented by the medical officers attached to divisional headquarters, by keeping in touch with officers commanding and with the medical officers in charge of units, could supervise and insure the accomplishment of that which legislation had ordained. The Divisional Sanitary Officer in particular should be ubiquitous on the march.

On the lines of communication and amongst stationary troops generally the prescribed sanitary organization should meet all requirements; but when a force is cut off from such means, and when the attention of those responsible for fighting units is naturally absorbed by other matters, an extension of our existing organization on the above lines would certainly appear advisable.

Judged in the light of preceding chapters, the keynote of military sanitation is not so much the destruction of dangerous

germs as the prevention of their evolution, and to effect this object ceaseless vigilance is essential.

A Sanitary Company R.A.M.C. Territorial Force has a peace establishment of one major, two captains, two subalterns, and a hundred of other ranks. The officers naturally have executive authority within the scope of their own duties. Two companies are provided in war establishments for army troops, and a certain number of men (R.A.M.C.), in proportions prescribed by regulations, for water duties. Besides the above, there is one sanitary officer attached to the headquarters of each division. Many of the officers are men who have already gained eminence in civil life, and all of them probably have administrative experience acquired in public health appointments.

For any system of sanitary organization in the field to be thoroughly successful it is absolutely necessary that the medical authorities should be kept constantly informed of the state of health of the respective units. With this object in view, a weekly return of sick might be rendered to the Divisional Principal Medical Officer, showing any particular incidence of disease, together with the sanitary conditions prevailing. It would be quite unnecessary, and tend merely to useless labour, to show a return of all forms of sickness; in fact, it would answer all requirements if the return only showed such diseases as are usually attributed to defective sanitation, and as a guidance to medical officers in charge of units a list of such diseases might be published in orders at the time the force takes the field.

The return should be rendered by squadrons, batteries, or companies, so that not only might the incidence of disease in the unit be shown, but likewise the incidence of disease in any part of such unit. The information should comprise the destination of all such men transferred sick.

A suggested form for this return is set forth below. Of course it might be necessary to include other diseases besides those named.

'Return of Sick in 1st Battalion —— Fusiliers for the Week ending January 16, 1910.

Companies.	Pyrexia of Uncertain Origin.	Enteric Fever.	Dysentery.	Diarrhœa.	Total.
A	4	—	—	—	4
B	1	—	—	1	2
C	1	—	—	1	2
D	—	—	—	—	—
E	—	—	—	—	—
F	—	—	—	—	—
G	—	—	—	—	—
H	—	—	—	—	—
Total ...	6	—	—	2	8

With the exception of the cases of Pyrexia of Uncertain Origin, and those of Diarrhœa, the general health of the Troops has been satisfactory; but, owing to the existence of active hostilities, it is very difficult to maintain a satisfactory standard of conservancy. Food, water-supply, and clothing are as described in my last report, and leave nothing to be desired; but the latrine trenches, and the removal of refuse generally, need more attention. The weather is very hot, and flies are abundant. The sick referred to above were transferred on the 13th inst. to No. 2 Stationary Hospital.

'—. —. ——,
'Captain R.A.M.C.

January 16, 1910.'

By means of reports of this nature the sanitary officer's attention will be drawn to points where his services are likely to be required, and much valuable time may thus be saved. In the above case the necessity for the earliest possible inspection would be evident. It would be a matter for regret if the personality of medical officers in charge of units were absorbed in that of the sanitary officer; the latter should be of the nature of an adviser in difficulty rather than an inspecting officer for disciplinary purposes. In case of war the medical officers in charge of units would probably be juniors in most cases, and a sanitary officer with previous experience of the field would be able to point out

the steps most likely to adjust themselves to service exigencies. As a general rule help and not blame should be the guiding-line of action for the senior to follow. By way of supplementing the weekly return from units, a return of men suffering from the special ailment in question should also be rendered weekly from the stationary hospitals to which the sick have been transferred. This return should show the date of arrival of sick, together with the ultimate diagnosis—if it has been impossible to form a diagnosis, the latter should be furnished as soon as possible—and also should be rendered by squadrons, batteries, or companies. By this means a history would be obtained of all doubtful cases in each unit, together with the circumstances under which such cases arose. An increase of clerical work is to be deprecated; but, on the other hand, if sanitary organization is to succeed, energy must be concentrated in the right channels.

CHAPTER XIII

PHYSICAL TRAINING

APART from the actual use of arms, the prime object of physical training is to fit the soldier to endure with impunity certain conditions which are generally inseparable from active hostilities in the field. It may here be observed that these conditions approximate to some extent those of primeval man—in other words, to that remote period in the world's history when our ancestors relied on physical strength, courage, and resource for the maintenance of life, and for whatever may have been their peculiar ideas of comfort and general well-being. When man spent his waking hours in pursuit of his prey and in cultivating the earth, and before the existence of large communities, disease-producing conditions must have been conspicuous by their absence. Speaking generally, the diseases to which man is most frequently the victim result either from infection from disease-producing germs, from chemical poisons formed within the body as a result of dietetic errors, from congestion caused by external chill, and, lastly, from the various tissue changes produced by over-indulgence in alcohol.

From these influences primeval man was in the main exempt. A life in the open air largely guaranteed him from the danger of germs, and the simplicity of his diet against that catalogue of diseases which accompany the customs of what is known as advanced civilization, while the natural clothing of the animal world, in the shape of furs, gave him the necessary protection against changes of temperature.

The noxious products of his body were carried away by the air and disposed of in the soil, and in both cases were taken up as food by the plant world. With the growth of large communities, man's own waste products caused his physical undoing ; the difficulty of getting rid of respiratory matter in defective dwellings, and the absence of any organized sewage disposal, brought about diseases which we seem to find almost inseparable from civilized life, and of which the vital causes cannot, except in a distorted intellect, be considered as having originated in special acts of creation.

Troops when in mobile bodies, and provided they are suitably fed and clothed, and have a reasonable allowance of sleep, enjoy all the advantages belonging to the natural state; and practical knowledge gained in war and on manœuvres has produced a general consensus of opinion that the sickness found in the field is inherent in camps, and is, as a rule, either mitigated or altogether removed even under exceptionally arduous conditions connected with the line of march. It is undeniable that the products of fatigue are poisonous ; but during war the chances of dying from such a cause are infinitesimal, while the chances of dying from a preventable disease are, to say the least of it, considerable. The manœuvres of 1909 are probably the most arduous that have taken place for years ; many regiments spent the night not only without shelter, but without blankets, while a hopelessly mistaken idea of maintaining health might have resulted in the constant provision of tents and the creation of those foul conditions which are directly conducive to sickness. It is a noteworthy fact that disease commonly makes its appearance in the field when the comforts of the troops are greatest, and once we grasp the fact that the bare necessities of life provide the surest means for the attainment of a high standard of health and efficiency, we shall have established a principle of prime importance in the art of military sanitation. With unsuitable or insufficient food, or deprivation of the natural protection against heat and cold, in the shape of woollen clothing, fatigue will open the door to a variety of diseases ; but

provided the troops are furnished with what the natural man demands, physical training in the form of exposure and strenuous work can practically be discounted in its bearing on health, except in a favourable direction. Place men in standing camps for long periods, and circumstances are entirely altered, as we have at once a state of things which resembles those obtaining when human beings first became aggregated into comparatively large communities, without the experience necessary to enable them to reckon with the new conditions of life.

Physical training is from the health point of view the acquisition of power to resist fatigue and climatic change, and if the above principles are sound, the attention of medical officers should be more constantly directed to the subjects of food and clothing than is sometimes the case at present.

With the advent of the Territorial Army, the subject of field training will assume an interest in the eyes of the nation that it has never done before, and the men who lately gave to the call of the country an answer of which we have good reason to be proud have, by splendid proof of unwearying energy and endurance, furnished an object-lesson which should go far to counteract the decadent tendencies of modern life.

To protect against cold and wet, heat-producing food and woollen clothing are necessary. As a heat-producing food of general applicability, cocoa can scarcely be rivalled, and by its stimulating effect it brings about a grateful sensation of cheerfulness and comfort. Wool is essential as a protection against the effects of wet for the following reasons: the great danger from wet clothes results from rapid evaporation and the conversion of the sensible heat of the body into latent heat, the latter maintaining the vapour as such; wool checks evaporation, and the danger of chill is consequently lessened; so even if a woollen garment is saturated with moisture, as is often the case after violent exercise, it can still be worn with little or no risk. Wool, also, being a bad conductor of heat, maintains the surface of the body at an equable temperature

(see p. 327). Of course, circumstances alter cases, and the application of these principles must be tempered with the exercise of common sense.

Marching.

The essence of good marching, whether during actual warfare or manœuvres, is the attainment of the objective in the least possible time. It follows that every particle of unnecessary transport is excluded from the column, and orders are issued to insure rigid compliance. The question as to what is and what is not actually necessary has never yet been answered; from the purely health point of view, this is essentially a matter for the judgment of the medical authorities, and if the principles already stated had due weight, would be greatly simplified. The lessons of South Africa are still fresh in the mind of the public, and instances from that campaign are not wanting in which the effect of wheeled transport has played a striking part. During the march from Estcourt to the Tugela, in the effort made during January, 1900, to turn the right flank of the Boers, the transport consisted of the South African trek waggon, and our progress was not accelerated by the fact that it rained in torrents, and that the waggons constantly sunk to the axles in the track of tenacious mud which formed the road between Estcourt and Frere. Speaking personally, I spent thirty-six hours on my feet, or in the saddle, in covering the distance—about sixteen miles—between Frere and the Little Tugela at Springfield Bridge.

Whether the amount of transport carried was absolutely necessary for the prosecution of active hostilities is not a matter which I am prepared to discuss, but I am perfectly certain it was not necessary for the health of the men; and, furthermore, it is probable that the rapid attainment of the objective might have obviated the concentration of troops between Ventner's Spruit and Spearman's Plain, where enteric fever made its appearance during the early part of the year. As long as the troops were moving, the sickness was relatively slight, and the example just referred to is one of many which go to prove that mobility is a factor of vital

consequence in the maintenance of health, as it is in the attainment of tactical success. It would be easy to pile up instances in which troops, in the total absence of anything worth calling creature comforts, have marched and fought, not only with untiring energy, but with increased effectiveness; and when the losses, once the weaklings and wastrels were accounted for, have mainly resulted from the cause which naturally attends the soldier's existence.

The details of Lord Roberts' historic march from Kabul to Kandahar are too well known to most of us to need mention here. Less familiar, possibly, are the examples of extraordinary endurance shown by the Valley Army under Stonewall Jackson in the American Civil War. By means of extreme mobility, Jackson was again and again able to put into practice the vital rule of successful warfare—viz., that of 'getting there first with the most men,' and so to crush his enemy in detail by sheer weight of overwhelming numbers. In fact, the series of brilliant victories won by the great leader were as much the result of rapid movement as of the fighting powers of his splendid troops. Human endurance has its limits; and as in mechanics, so in war, the breaking strain will at last be reached, and Jackson never by useless calls wasted the energy and endurance of his men. But when occasion required, there was no rest until the object was attained, and the results of his leadership justified the words in the Southern soldier's song, 'The foe had better ne'er been born who gets in Stonewall's way.' 'His victories were won rather by sweat than blood, by skilful manœuvring rather than sheer hard fighting.' "I had rather," he said, "lose one man in marching than five in battle;" and in order to achieve an easy triumph his men were marched till they dropped in scores. But the marches which strewed the wayside with the footsore and the weaklings won his battles. The enemy, surprised and outnumbered, were practically beaten before a shot was fired, and success was attained at a trifling cost.' *

* 'Stonewall Jackson,' by Lieutenant-Colonel G. F. R. Henderson, vol. ii., p. 594.

As a contrast to the above, MacMahon, whose movements during the summer of 1870 were largely determined by the varying political currents in Paris, wore out his troops before the Battle of Sedan by useless fatigue and privation, so that the gallantry of the French was heavily discounted by the exhausted condition in which the men were forced to meet the invaders.

'As the frequent marches and counter-marches both by day and night, accompanied with most insufficient food, had sorely tried the strength of the troops and had greatly shaken their confidence in their leaders, discouragement to a most serious extent now took fast hold of the army of Châlons. General de Wimpffen . . . had proceeded from Mézières, through Douzy, to Amblinont. On reaching that place in the afternoon of the 30th, he met crowds of fugitives of various corps streaming back from the battle, who cried loudly for bread, and made known their state of depression and exhaustion, while their leaders appeared helpless and indifferent.

'In consequence of the utter want of discipline amongst the troops, the General had some difficulty in halting a number of men, even after he had pointed out to them that they were not pursued. The retreat of the army upon Sedan, commenced towards evening, was continued during the night along roads encumbered by carriages of every sort. Troops of all arms, intermingled pell-mell, endeavoured, every man for himself, to reach the prescribed destination. Where the roads were blocked, by-paths were taken, and, from want of acquaintance with the locality, many bodies of troops took directions which spared them from the subsequent catastrophe.' *

Instances such as the above are worthy of careful attention, for among the many subjects which come within the scope of the medical officer, one of the most important is

* 'The Franco-German War.' Translation from the German official account by Captain F. C. H. Clarke, R.A., part i., vol. ii., pp. 288, 289.

the effect of physical training as a factor in assuring the mobility essential to military success.

The general rules governing the march are matters of common sense. They mainly consist of allowing frequent short halts instead of infrequent long ones; of keeping open formation as far as possible; of covering refuse of all sorts before resuming the line of march after halts; and of ordinary intelligence in the care of the feet. Water-bottles should be filled before starting, either with water or tea, and a pair of socks carried by each man besides those actually worn. Infantry should not as a rule march near guns or transport, as the dust raised by gun carriages and waggons is most irritating, and the frequent halts caused by blocks are likely to be more tiring, to the men, than steady movement. A light midday lunch of soup and biscuit—preserved soups would be useful for the purpose—is far better than a solid dinner accompanied with beer, and therefore the most substantial meal of the day should be postponed until the end of the march, when alcohol, if obtainable, may be consumed in reasonable quantities with great advantage. Sleep is a matter of prime importance, and 'lights out' might be sounded an hour or two earlier than usual, as circumstances seem to require. The sooner both officers and men are asleep, the better. When strenuous work has to be done, physical and mental energy should be rigidly economized.

The method of carrying equipment is of vital consequence, and great improvements in this direction have been lately effected. To understand the principle of correct adjustment, we must remember that the human body in the erect position, with the feet close together, is in a state of unstable equilibrium; meaning that if the centre of gravity is displaced it will move farther and farther from its original position in relation to the earth, and thus tend to bring about a fall of the whole body; secondly, we must remember that we diminish stability by raising the centre of gravity; and thirdly, that the diminution of stability will increase with the distance that a vertical line dropped from the centre of gravity falls outside the basis of support. By placing a heavy weight

between a man's shoulders, we raise the centre of gravity of the man and the weight combined, and we also tend to throw the vertical line from the centre of gravity outside the basis of support. To overcome the tendency to fall on his back, the man naturally stoops forward, thus lowering the

FIG. 5.—BRITISH METHOD OF CARRYING EQUIPMENT—OLD STYLE. PRIVATE OF THE SUFFOLK REGIMENT—FRONT VIEW.

FIG. 6.—BRITISH METHOD OF CARRYING EQUIPMENT—OLD STYLE. PRIVATE OF THE SUFFOLK REGIMENT—BACK VIEW.

Photographs by Captain H. d'A. Smith, the Suffolk Regiment.

centre of gravity, and bringing a vertical line dropped from the latter within the basis of support. If, on the other hand, the man retains the erect position, he can only do so at the expense of muscular effort (see Figs. 9 and 10). To obviate these disadvantages, the new equipment places a large pro-

portion of the weight on the waist-belt, the latter in turn resting on the pelvic bones, which, being of the nature of a mechanical support, are so far economical of muscular effort.

The farther a weight is from the centre of gravity the greater will be the leverage exerted ; so that, as well pointed

FIG. 7.—BRITISH METHOD OF CARRYING EQUIPMENT —NEW STYLE. PRIVATE OF THE GRENADIER GUARDS. WEIGHT CARRIED ABOUT 45 POUNDS—FRONT VIEW.

FIG. 8.—BRITISH METHOD OF CARRYING EQUIPMENT —NEW STYLE. PRIVATE OF THE GRENADIER GUARDS—BACK VIEW.

Photographs by Sergeant Gregson, R.A.M.C.

out by Munson, a light weight far from the centre of gravity can balance a heavier weight which is placed nearer the point in question.

The new equipment so distributes the articles to be carried that the weights counterbalance each other, and the vertical from the centre of gravity falls midway within the

basis of support, so that muscular effort which would otherwise be necessary to maintain balance is economized.

It needs no great knowledge of physiology to see that if a man is to march effectively, the heat generated by the exercise must be balanced by loss from the surface. The loss

FIG. 9.—FRENCH METHOD OF CARRYING EQUIPMENT, DIVISION D'ALGER. WEIGHT CARRIED ABOUT 70 POUNDS —FRONT VIEW.

FIG. 10.—FRENCH METHOD OF CARRYING EQUIPMENT, DIVISION D'ALGER — BACK VIEW.

takes the form of latent heat, and the latter holds the sweat in the form of vapour ; but with a tightly buttoned jacket evaporation is checked, and the temperature may consequently rise to a dangerous height, while the sweat-saturated shirt adds to the weight which the soldier carries. In the old days, when efficiency was sacrificed to smartness, sunstroke

on the line of march was not uncommon; but modern enlightenment aims at health and comfort rather than at so-called 'appearances'; and the new equipment allows the soldier to unbutton his jacket, and so to take advantage of the heat-regulating arrangement provided by Nature for his safety. Another excellent point in connection with equipment is that

FIG. 11.—SWISS METHOD OF CARRYING EQUIPMENT. WEIGHT CARRIED ABOUT 60 POUNDS—FRONT VIEW.

FIG. 12.—SWISS METHOD OF CARRYING EQUIPMENT —BACK VIEW.

it can be readily removed and readily readjusted, so that a man can take advantage of short halts. The arrangement is smart and soldier-like, and sound both in theory and practice. The weight is slightly in excess of the old equipment, but this disadvantage is amply counterbalanced in other directions. It will be seen that the bandolier, with

ammunition carried across the chest, has disappeared in the new arrangement (see Figs. 7 and 8, also Figs. 11 and 12). It is evident that a weight pressing on the respiratory organs is a serious impediment to exertion, and particularly so when negotiating a hill (see Fig. 14). It has been stated that the close application of the sack makes the men uncomfortably warm, but the Committee on the Physiological Effects of Food and Training on the Soldier find that this is 'a disadvantage which could be easily overcome.'

FIG. 13. — UNITED STATES METHOD OF CARRYING EQUIPMENT. ESTIMATED WEIGHT 46½ POUNDS.

There must be no lack of water on the march. If men are to remain healthy while undergoing exertion, they must be able to make good the loss of moisture from the skin. To tell a man to avoid drinking when he is thirsty is a violation of the laws of health, and is just about as sensible as to advise a man to avoid food when suffering from the pangs of hunger. Without an adequate supply of water, the waste products resulting from exercise accumulate in the blood and act as a poison to the system. Of course, if the supply is likely to run short, men must be enjoined to exercise self-restraint in having recourse to the water-bottle. Young soldiers, unless watched, will drink, not because they are thirsty, but simply for something to do.

It must always be remembered that the temperature rises naturally during exertion, so that the thermometer is not of the same value during the march as at other times.

The newly-introduced system of Swedish gymnastics

FIG. 14.—TERRITORIALS ON THE MARCH NEAR ALDERSHOT—OLD EQUIPMENT.
Photograph by Gale and Polden, Aldershot.

aims at the harmonious development of heart, lungs, and muscles, and, judging by the splendid marching at the recent manœuvres, the result is all that can be desired. In the words of the manual: 'It is not sufficient to train the muscles alone, and to neglect the heart, lungs, and other internal organs, for it is on the internal organs that the body depends, not only for its health, but for its very existence.'

As the exertion undertaken at the time of the exercise seems trivial as compared with the old system, men sometimes think that they are doing little or nothing, but the subsequent stiffness shows the error of the idea. A highly important point in connection with the exercises is the fact that the breathless strain caused by the superseded method is not felt, and there has thus been a gratifying absence of circulatory troubles among the men trained according to the new scheme, as shown in following table:

Period.	Ratio of Invalids discharged for Heart Affection.
	Per 1,000.
1901	6·26
1902	5·73
1903	3·62
1904	2·88
1905	3·13
1906	2·52
1907	2·47
1908	1·86

(Army Medical Report for 1908, p. 7.)

All medical officers now undergo the prescribed course of training, and thus acquire a thoroughly practical knowledge of its effects. It is interesting to learn that in France the same form of instruction is carried out under conditions which would be impossible in this country, and is regarded with rather mixed feelings.

'Chaque année, à l'arrivée des recrues, les compagnies se divisent en pelotons qui, sous les ordres d'un officier, s'en

vont cheque matin et chaque soir dans les cours du quartier, sur la place publique, se livrer à cette comédie burlesque, qui consiste à remuer sans profit bras et jambes pendant des heures consécutives. Quand je dis sans profit, je le prouve. Notre soldat, dès le mois de novembre, époque où commencent les froids, est toujours fortement vêtu. . . . Ayant aux pieds des souliers pesants; vêtu d'un caleçon, d'un pantalon de drap recouvert du pantalon de treillis; le torse enveloppé d'une flannelle, recouvert d'une chemise, d'un gilet, d'une petite veste et d'un bourgeron, le tout saucissonné par le courroies du sac, des cartouchièments et du ceinturon, comment voulez-vous que le troupier puisse exécuter avec profit le mouvement qu'on lui a commandé ?' *

A point recently brought to notice in public by the commanding officer of a distinguished regiment is the prime necessity for absolute physical fitness on the field of battle. With long-range weapons the time that attacking infantry must be under fire is relatively great, and therefore, other things being equal, the more rapidly the objective can be attained, the fewer the number of casualties, and the greater the chance of success.

Games, boxing, and sports generally, are splendid helps to physical training; their popularity is not likely to lessen, and there is, therefore, no need to mention them further.

Singing is a valuable exercise for the respiratory organs, especially when practised in the open, but in a stuffy room its advantages are open to question. It produces cheerfulness and good temper, and helps to remove the sense of fatigue. It is a matter of common knowledge that tired men will step out well to a 'catchy' air, so that a popular officer or man with a good voice is really a valuable acquisition on the line of march. Singing, however, may have other results than that of cheering men for a brief period. The hygiene of mind and body are well known to be interdependent, and good sentiments, or the reverse, produced by singing may be translated into actions of a heroic or of an actually diabolical nature.

* 'Notre Soldat,' Lacland, p. 71.

Fortunately, we are not a particularly emotional people, and we have an instinctive dislike to sentiment; but, on the other hand, common sense tells us that we cannot afford to despise sentiments which have contributed to the results of military operations, and have, therefore, helped to direct the history of the world. At Dunbar, for instance, Cromwell's Ironsides, when lined up for the charge that shattered the Northern Army, sang the 68th Psalm, and it is not difficult to imagine the effect on men whose spirits were already fired with the prospect of battle and ardour for their cause. No victory could have been more decisive, while the frightful list of killed, and the wholesale capture of prisoners, guns, and baggage, are evidence of the ferocity of the struggle and the relentless nature of the pursuit.

At the Battle of Leuthen the Prussian troops, moving into action, sang 'Ein feste Burg ist unser Gott' with something more than vocal effect, and Luther's hymn has now become the battle song of the German Army. As it was sung by the troops of Frederick in 1757, so it was sung by the troops of William in 1870, and was doubtless one of the many factors contributing to the series of events that culminated in the establishment of a united Germany.

It is difficult to picture anything more dramatic, and at the same time more severely practical, than the closing phase of the Battle of Jemappes, when the rallied Republican Centre, led by Dumouriez in person, and singing the 'Marseillaise' as one man, advanced to the final attack, and carried the Austrian position at the point of the bayonet, with a courage that nothing could resist. The scene is thus described in the words of Carlyle:

'November 6, 1792, was a great day for the Republic * * * for Dumouriez, overrunning the Netherlands, did on that day come in contact with Saxe-Teschen and the Austrians. Dumouriez wide-winged, they wide-winged; at and around the village of Jemappes, near Mons. And fire-hail is whistling far and wide there, the great guns playing, and the small; so many green heights getting fringed and maned with red fire. And Dumouriez is swept back on this wing, and swept back

on that, and is likely to be swept back utterly; when he rushes up in person, the prompt Polymetis; speaks a prompt word or two; and then with clear tenor pipe uplifts the hymn of the "Marseillaise," *entonna la "Marseillaise,"* ten thousand tenor or bass pipes joining; or say some forty thousand in all; for every heart leaps at the sound, and so with rhythmic march melody, waxing ever quicker, to double and treble quick, they rally, they advance, they rush, death defying, man devouring; carry batteries, redoubts, whatsoever is to be carried; and, like the fire whirlwind, sweep all manner of Austrians from the scene of action. Thus, through the hands of Dumouriez, may Rouget de Lille, in figurative speech, be said to have gained, miraculously, like another Orpheus, by his Marseillaise fiddle-strings, a victory of Jemappes; and conquered the Low Countries.' *

For an example of 'pugnacious piety' the American song 'John Brown,' has few equals. It was written in 1860 in honour of a negro emancipator who, in consequence of an over-zealous application of his principles, perished by the hands of the hangman. It gained an enormous popularity among the Federals, and reference to the history of the times leaves little doubt that it contributed in no slight degree to the result of the war, as it fired the soldiers of the North with extraordinary enthusiasm, and so enabled them to show a steadiness and courage admirable in the case of partially disciplined men. The opening line, 'My eyes have seen the coming of the glory of the Lord,' is certainly of a fairly stimulating nature, and the whole composition is saturated with that peculiar form of religion which, coupled with the genius of their leader, made Cromwell's troops at once the terror and the envy of the civilized world.

The training of the soldier should be one not only of physical, but also of mental hygiene, and the judicious encouragement of singing will go some way towards the attainment of a double object.

* 'History of the French Revolution,' by Carlyle. See also 'Vie et Mémoires du Général Dumouriez' (Paris: Beaudoin Frères).

CHAPTER XIV

WATER

THE water that supplies our daily needs has its origin in the rain that falls on the surface of the earth. On reaching the ground, part of the rainfall evaporates, part of it sinks into the soil, and a third part runs off to swell the volume of water contained in brooks, rivers, lakes, or the sea. From these and all other collections of water, vapour is drawn into the atmosphere by the heat of the sun, and when from any cause the temperature falls to the necessary degree the moisture is condensed into rain, and so returns again to the earth. A constant circulation of water thus takes place, and if this circulation were to cease, life, as we know it, would rapidly come to an end.

The main sources of water-supply for communities are springs, wells, rivers and other watercourses, lakes, and surface collections.

SPRINGS.

It has just been stated that part of the rainful soaks into the ground. The depth to which it penetrates is largely determined by the nature of the soil and the proximity and permeability of neighbouring strata. In general terms water descends until it reaches a layer of stiff clay or other stratum through which it is unable to pass, and its further course is then determined by the contour of the land and the geological nature of the surroundings. It is this body of water which has sunk from the surface that is spoken of as ground water. It is plain that with a

loose soil such as sand or gravel, and an impermeable stratum near the surface, the ground water must necessarily stand high; it is equally evident that with the same soil, but with the impermeable stratum at a greater depth, the ground water will recede to a corresponding extent.

The ground water is subject to the same forces as water anywhere else, and its general course, therefore, is guided by the stratum on which it lies. Suppose, for instance, rain water, having sunk through a loose sandy soil on a hillside, meets a stratum of clay a few feet from the surface, clay being impermeable to water, the directly downwards course of the latter is now barred, and a direction has to be

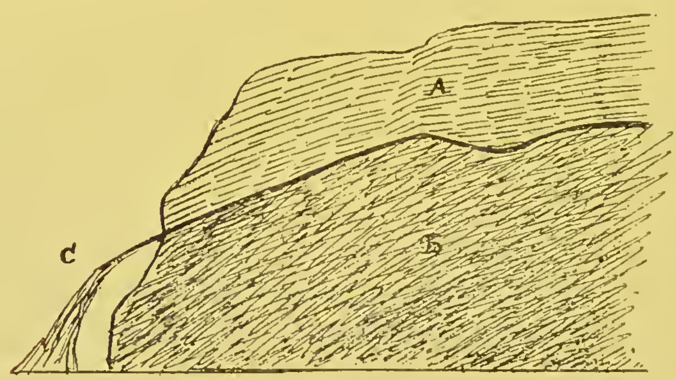


FIG. 15.—DIAGRAM SHOWING FORMATION OF LAND SPRING.

A, Superficial soil containing ground water; B, impermeable stratum; C, spring.

assumed according to the inclination of the underlying obstacle. If, for example, the clay crops out on the side of a hill, either at a dead level or at a gradient corresponding more or less with that of the surface, then at that particular point the water, having no other direction in which it can possibly move, must necessarily issue from the earth in the form of a spring (Fig. 15).

Springs formed in this way are known as land springs, and a knowledge of their mode of origin is important from the fact that they have an altogether undeserved reputation for excessive purity. As the rain water sinks into the land it becomes highly charged with carbonic acid. This acid is derived from the decomposing remains of plants and

animals which are found in the superficial layers of the soil; it exercises a solvent effect on certain minerals, and is the cause of the sparkling appearance and pleasant taste which are common characteristics of spring water.

It can now easily be understood that the desirability, or otherwise, of a spring for drinking purposes, must partly depend on the mineral substances which are held in solution, and partly on the presence of organic impurities in the soil through which the water has passed.

It is a most interesting and important fact that grossly polluted water may present the most attractive features in the direction of appearance, taste, and absence of odour, while possessing, to the full, disease-producing powers of a sufficiently deadly nature. This fact is now well known by sanitarians, and statistics go far to prove the spread of enteric by water from sources now in question (Gärtner).

In the absence of habitations it is unlikely that spring water would be otherwise than safe, but it is a useful fact to remember that a source of this nature is in itself no absolute guarantee of purity. On the march and on manœuvres the choice of a water-supply is naturally a matter of great importance. Officers and men are under the popular impression that spring water means safety. This may be perfectly true in a large number of cases; but before sanctioning the use of such water it is only right to ascertain the absence of all likely sources of impurity in the immediate neighbourhood.

Another form of spring, to which the above objection in connection with organic pollution does not apply, furnishes water from a considerable depth, and is contained in some regular geological formation. The mineral constituents of these springs vary greatly, and render them at times quite unfit for use; but the great thickness of the strata through which the water percolates removes by its filtering action the dangers which accrue from impurities in the soil. These springs, as a rule, flow all the year round, while the land springs are directly dependent on the rainfall.

There are other springs, known as intermittent springs. They do not possess the same importance as those which

have been discussed. They are formed when a valley reaches the highest level of the ground water. As the ground water rises, a spring is formed, but it disappears as the ground water recedes in times of lessened rainfall.

If it can possibly be avoided, men should never be allowed, except on duty, to approach a spring used for the supply of a camp. Sentries should be immediately posted over all such sources, no matter how short the period for which the troops remain in the locality.

If the new pattern carts are not available, the water should be brought into camp by means of lead piping, as the latter can readily be coiled and might, when deemed advisable, be carried as necessary transport. Hose tubing is, of course, much lighter, and there does not appear to be any reason why it should not, on occasion, be made to answer the same purpose. I have seen the surface of the ground near an excellent spring rendered abominably foul by the number of men who were constantly drawing water, either as fatigue-parties, or for their own individual purposes. The camp was about a quarter of a mile distant, but for some reason it was not considered necessary to lay on a pipe, and without taking the question of inconvenience and labour into consideration, the actual source of supply stood in danger of being hopelessly polluted.

Wells.

Wells are divided into two classes—viz., shallow and deep.

A shallow well corresponds in its formation to a land spring, as it only contains the water in the upper layers of the soil, above the highest impermeable stratum. Once the ground water is reached, by the necessary excavation, a well is formed. It is easy to see that a supply of this kind is not satisfactory, partly because in times of drought it is apt to run dry, and partly because organic impurities in the soil, often including the leakage from cesspools and privies, are quite likely to be washed into the water by heavy rainfalls, or else to soak through of themselves.

The rural districts in England are still supplied to a most undesirable extent by shallow wells, so that it is quite worth while to bear this danger in mind when troops, at home, are on manœuvres or on the line of march. It would be a most dangerous error to be deceived by the clear and sparkling appearance which such waters often present.

The number of shallow wells in India is enormous. Many of them are simply holes dug in the ground; they are then spoken of as 'kucha' wells, but if lined with masonry, as 'pukha.'

The native of India attends to certain functions of Nature without the regard which Western races commonly pay to the question of locality—in fact, with certain reservations, he acts on the convenient principle that there is no time like the present and no spot so suitable for the purpose as that on which he happens to be standing. As this primeval mode of responding to natural wants obtains more largely in the country districts than elsewhere, it is not a matter of surprise that the soil in and about the native villages is absolutely saturated with waste organic material. The water-supply of Indian villages is almost invariably obtained from wells, in which the water may, even in the hot weather, be within a few feet of the surface, so that under the influence of rain the polluted substance of the soil has every possible facility for the wholesale poisoning of native communities.

The 'kucha' well is, of course, singularly well adapted for the reception of all kinds of unnameable filth.

The wells, whether 'pukha' or 'kucha,' being almost invariably uncovered, are also open to direct pollution of a variety of sorts, including that which results from the use, in lieu of bucket, of a filthy skin which is handled in turn by beings to whom the word 'cleanliness' has only a vague and uncertain sound. Among other forms of pollution, the presence of a human corpse occasionally finds a place, as a jealous wife has, before now, been known to drown herself in a well, in the hope of poisoning her successful rival; the incidental damage to uninterested and innocent persons being entirely overlooked.

It would be unfair to assume from the above that Indian wells are invariably of the above nature. Many wells are of great depth, and contain excellent water; but no matter what good results analysis may reveal, the absence of protection should invariably call for the most rigorous measures of precaution and purification whenever troops are in sanitary camp, or when, for any reason, they are supplied from such sources as those now in question. Out of thirteen samples of water drawn from different wells in the Ghaziabad district, I found free ammonia in all, nitrites in twelve, and colon-like forms in six. The examination was made fully two months after the end of the rains. The wells were all 'pukha,' and were to form the water-supply of various camps.

Deep wells are either those which are sunk to a considerable depth through regular geological formations, or through an impermeable stratum, before reaching water. Artesian wells are one form of deep well, the water being confined between two impermeable strata, and the intervening permeable soil outcropping on the surface at some point higher than that at which the well is sunk. Water finds its own level, so that as soon as the upper impermeable layer is pierced, the water flows out with great force. The greater the difference in vertical height between the outcrop and the point at which the well is sunk, the greater will be the force of the issuing stream. Deep wells are stated to be common in the Punjab, but although they are free from certain of the dangers of shallow wells, they are none the less open to direct contamination.

It may here be noted incidentally that it is a frequent practice of Indian natives, when drawing up their supplies by hand, to stand on a plank placed across the top of the well, and dirt from their feet can thus easily be transferred to the water.

Water is usually drawn by bullocks, the animals hauling the rope down an inclined plane, known as a 'bullock run' (Fig. 16). The run is nearly always in a foul condition from the presence of the animals, so that a constantly present source of pollution has to be reckoned with.

No uncovered Indian well should be looked on as safe, and it is an utterly wrong principle to sanction the use of any such water on the ground of satisfactory analysis. At any moment pollution of the worst kind may occur, so that an analysis which may be perfectly correct at the time it is carried out, may almost immediately afterwards become utterly valueless as a sanitary guide.

Pinking the wells is a custom which can only claim respect on the score of antiquity, as, apart from the question of the

FIG. 16.—'BULLOCK RUN' OF NATIVE WELL IN HOSPITAL COMPOUND, DELHI.

strength of permanganate of potash necessary to produce satisfactory bacterial results, it is a fact that this substance does not wholly part with its oxygen except in the presence of an acid and when heated to a certain temperature—conditions which are always attended to in the laboratory estimation of organic oxidizable matter. As neither of these conditions can possibly be fulfilled in the process of pinking, the value of the measure is discounted at once.

It may be added that permanganate of potash is

useless for the destruction of the enteric bacillus, even in quantities which would render water absolutely undrinkable.

The upper 6 to 12 feet of every well should be water-tight, and the top so finished that no surface water can possibly gain access. It is also very desirable that the top of the well should be brought up 6 to 12 inches above the ground surface, and covered with a proper flag-stone or iron cover (Thresh). The water should always be raised by a pump, and never by a bucket.

Rivers.

River water should generally be viewed with suspicion, owing to the sources of pollution which are commonly present; but whether such water should be absolutely condemned or otherwise must depend on a variety of contingencies which are matters of common knowledge, or, at any rate, of common sense.

Small watercourses often yield excellent supplies.

Lakes.

As in the case of rivers, no particular rule can be laid down concerning the purity of lake water. Each source of this nature must be judged on its own merits. Lakes are certainly far more likely to be pure than rivers, and many large towns, notably Glasgow, are well supplied from lakes with water which, both for abundance and purity, leaves nothing to be desired.

Surface Collection.

This often forms an excellent source of supply, and will be further considered later on.

Collection, Purification, Distribution.

Now that isolated military communities, like those located in the counties of Hants, Surrey, and Wilts, have come into existence, troops are likely to be more dependent than formerly on water-supplies collected, stored, and distributed by the military authorities, instead of by municipal bodies, so that a knowledge of this branch of sanitation is essential for the medical officer. Water may be obtained from any

of the sources which have been mentioned—namely, wells, springs, streams and rivers, and lakes—or else gathered off the surface of the land. In the last case, collection may be effected by means of a system of small artificial channels, and the water finally led into a reservoir.

Reservoirs are constructed by excavation or embankment, and are commonly rendered water-tight by a core of clay puddle. The outer sides are protected by grass, and the inner sides by a stone dressing. The number of days' storage to be allowed is arrived at by Hawkely's formula; this is, $D = \frac{1,000}{\sqrt{F}}$. D is the number of days and F the average rainfall during three consecutive dry years, or about four-fifths of the average. Twenty gallons per head per diem is a fair allowance, and 30 gallons a liberal one; the actual amount required depends, among other things, on the presence or otherwise of water closets. The water is conveyed away by means of iron pipes. The pipes are usually cast-iron; they are very liable to corrosion when conveying soft waters; this defect can be remedied by lining the pipes with pitch (Angus Smith's solution), or else by heating them to white-heat and then exposing them to superheated steam. The latter is known as Barff's process. Lead pipes, known as service-pipes, form the connection between the iron pipes and dwellings. It has long been held that lead pipes, being readily acted upon by soft waters, are a source of danger to consumers. Experience, however, shows that these apprehensions are largely groundless.

Spring and surface collection with storage in reservoirs is the system which exists at Bourley, near Aldershot, and by which the garrison is, in large part, supplied. The gathering-ground is at the western end of the Long Valley. Pollution of the water is possible, but unlikely. The locality is thickly wooded, and, as it presents features of great natural beauty, it attracts a certain number of trespassers, whom there is no means of excluding. The superficial soil is sandy, and the water is soft and of great purity. The impounding reservoirs are three in number; an analysis of the water, which I was officially called upon to make, gave most excellent results,

except that in one case there was evidence of vegetable contamination, but this defect proved to be entirely due to an accidental cause which was easily remedied, and, with reasonable precautions, unlikely to occur again. At the mounted infantry camp at Garrison Gorse, about one mile to the north-west of Bourley, the water is drawn from wells in the chalk. It is organically pure, but its hardness renders it undesirable for either drinking or washing. These two localities furnish good examples of some of the respective advantages and disadvantages of two of the principal modes of water-supply. In one case the water was soft, palatable, and otherwise excellent, but not free from possible pollution; in the other case, absence of any dangerous pollution was to some extent discounted in value by the presence of an undesirable chemical constituent—namely, chalk.

In inspecting a gathering-ground there is another question to be kept in mind besides that of possible sources of pollution, namely, the presence of peat. It is well known that peaty waters have a remarkable effect on lead pipes, and when the latter are in use great care should be exercised in ascertaining whether any part of a collecting area consists of the above vegetable formation. This matter will be referred to in greater detail later on.

In cases where purification on a large scale is necessary, the plan to be adopted would probably be settled at headquarters; but at some stations abroad the medical officer may be called upon to give his opinion as to the suitability of any proposed scheme, and a decision must be arrived at in accordance with well-known sanitary principles, and with due regard to local conditions. Rules adapted to meet every variety of circumstance cannot be laid down; it may, however, be briefly stated that the most effectual means of water purification for a community is storage followed by sand filtration. The filter-beds commonly consist of successive layers of fine sand, coarse sand, fine gravel, coarse gravel, and pebbles. The total thickness of the beds varies from 4 feet to 8 feet. The head of water allowed in the beds is commonly one of 4 feet or 5 feet, but 3 feet or even less is safer.

The formation of a gelatinous film on the surface of the

filter is essential. This film is deposited from the water, and consists mainly of intercepted organic matter and bacteria. If due care is taken, about 98 per cent. of the microbes present in the unfiltered water are removed; but to effect this object two conditions appear to be necessary: firstly, that the gelatinous film should not be disturbed, secondly, that the rate of filtration should not exceed 4 inches per hour. These are both points which medical officers would do well to bear in mind.

The gelatinous film takes two or three days to form after the water has been led on to the filter-beds. The film gradually increases in thickness, the rate of filtration decreasing in inverse ratio, and ultimately so far blocks the passage of the water that removal is essential. This is done by scraping, and the sand is then washed, with a view to future use, and fresh sand applied. The water should remain on the beds for twenty-four hours before restarting filtration; and the water which passes through the filter should not be used for at least three days, as the absence of the film allows the passage of germs which it is the object of the process to arrest.

In Canada and in the United States it is common to add aluminium sulphate to the raw water; the salt, by interaction with alkaline carbonates present, forms a gelatinous precipitate of aluminium hydrate, the latter entangling and carrying down to the surface of the sand filter a variety of suspended matter, including germs, and thus forming an immediate filtering medium.

An interesting paper, read by Professor Starkey, of the McGill University, Montreal, at the Annual Meeting of the British Medical Association in 1906, gave details in connection with the above method. The chemical reaction, as described by Professor Starkey, is as follows:

$$Al_2SO_4)3 + 3CaCO_3 + 3H_2O = Al_2(OH)_6 + 3CaSO_4 + 3CO_2.$$

This is known as the American or mechanical filter system, and was first used in paper-mills to remove the larger particles which would interfere with the successful treatment of the product.

Speaking generally, the effect of a sand filter can be regarded as threefold :

Firstly, its purely mechanical effect as a strainer.

Secondly, its chemical effect—that is to say, the oxidation that takes place in the substance of the filter, and which is due to the presence of air in the interstices between the particles of sand.

Thirdly, its vital effect—that is to say, the conversion of organic into inorganic matter by the action of microbial forms.

A comparatively recent feature in regard to the purification of water, which the community owes to Dr. A. C. Houston, is now occupying attention. At a meeting of the Metropolitan Water Board, held on July 17, 1908, the Director of Water Examination—Dr. A. C. Houston—set forth the result of experiments which make clear the fact that there is in stored water a relatively rapid disappearance of the germs which are regarded as being significant of danger, notably the typhoid bacillus. At a meeting of the Board on March 26 of the following year, Dr. Houston presented the results of further investigations in regard to storage. The chief points in this connection were summed up as follows :

'(1) It reduces the number of bacteria of all sorts. (2) It reduces the number of bacteria capable of growing on agar at blood-heat. (3) It reduces the number of bacteria capable of growing in a bile-salt medium at blood-heat, chiefly excremental bacteria. (4) It reduces the number of coli-like microbes. (5) It reduces the number of typical *B. coli*. (6) It alters certain bacteriological river-water ratios; for example, it reduces the number of typical *B. coli* to a proportionately greater extent than it reduces the number of bacteria of all sorts. (7) Storage, if sufficiently prolonged, devitalizes the microbes of water-borne disease—for example, the typhoid bacillus and the cholera vibrio. (8) It reduces the amount of suspended matter. (9) It reduces the amount of colour. (10) It reduces the amount of ammoniacal nitrogen. (11) It reduces the amount of oxygen absorbed from permanganate. (12) It usually

reduces the hardness, and may reduce (or alter the quality of) the albuminoid nitrogen. (13) It alters certain chemical river-water ratios—for example, the colour results improve more than the results yielded by the permanganate test. (14) It has a marked "levelling" effect on the totality of water delivered to the filter beds. (15) Storage tends generally to lengthen the life of the filters. (Only under exceptional conditions is the converse true.) (16) An adequately stored water is to be regarded as a "safe" water, and the "safety change" which has occurred in a stored water can be recognized by appropriate tests. (17) The use of stored water enables a *constant* check to be maintained on the safety of London's water *antecedent* to and irrespective of filtration. (18) The use of stored water goes far to wipe out the gravity of the charge that the chief sources of London's water supply are from sewage-polluted rivers. (19) The use of adequately stored waters renders any accidental breakdown in the filtering arrangements much less serious than might otherwise be the case. (20) The habitual use of stored water would lighten the grave responsibilities of the Water Board as regards the safety of the London water-supply, and would tend to create a sense of security amongst those who watch over the health of the Metropolis' (*British Medical Journal*, April 3, 1909).

It has been objected to the system of prolonged storage that the gelatinous layer, sometimes referred to as the 'blanket' or the 'skin,' would not be as germ-proof as that resulting from unstored water, but Dr. Houston shows that this possibility need not be a source of much anxiety.

At every military station it should be the duty of the medical officer in charge to make himself acquainted with the methods in force. At Worcester, for instance, the supply is drawn from the polluted water of the Severn, which receives the drainage of an extensive district, including in particular the town of Stourbridge. It is quite plain, therefore, that the sand filters in use constitute the only barrier against serious possibilities in the form of epidemic disease.

When I was Sanitary Officer, Western Area, Southern Command, I was indebted to the Medical Officer of Health, Dr. Mabyn Read, for much useful information affecting this matter, and I learned that the efficacy of the filters is constantly tested by bacteriological examination of the water. It was, in consequence, recommended that the medical officer in charge at Norton Barracks should keep himself informed as to the results of the bacteriological reports, and should base measures, in regard to boiling of water, in accordance with information received.

The above circumstance is worth citing as an example of how the health of troops may be protected by keeping in constant touch with the local municipality. Another example of how trouble may be spared by the above course may be of interest. In the autumn of 1906 I found that the Devonport water revealed the presence of *B. coli* in highly suspicious numbers. After consultation with the Administrative Medical Officer, I approached the local authorities, who most courteously invited me to inspect the whole of the waterworks and gathering-ground, in conjunction with the two Medical Officers of Health and the Municipal Engineer. The water was found to be collected on Dartmoor, about two miles east of the convict prison, and the solitary nature of the district placed the possibility of human contamination outside the bounds of reasonable possibility; and although it must be admitted that a pipe line might very well have replaced the open leat which conveyed the water through part of its course, I did not consider that any further apprehension need exist as to the safety of the garrison at Devonport. A pipe line at a suitable depth would have entirely obviated the serious inconvenience which had, on occasion, been found to result from the freezing of the leat and the consequent deficiency of water in the borough.

A method of purification which should have good results is that adopted by the Candy Water Filter Company. The water, having first been exposed to the action of compressed air, is passed through successive layers of silex, polarite, and silicious sand. It is claimed that, by the oxidizing

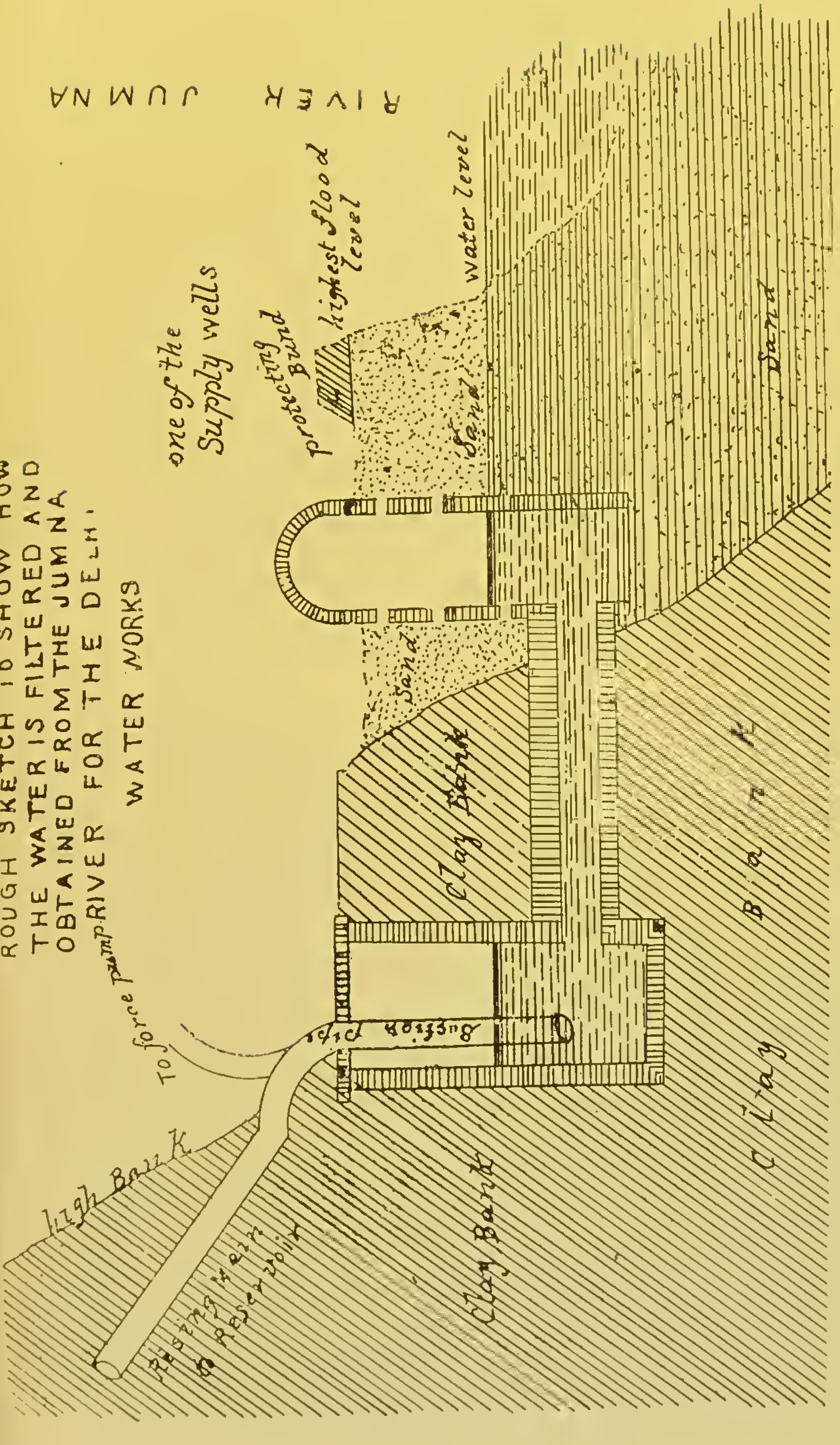


FIG. 17.—ROUGH SKETCH OF DELHI WATERWORKS.

action of the compressed air and the polarite, coupled with the effects of mechanical filtration, all impurities are removed.

Of course, the source makes an enormous difference in the care to be exercised. In a station like Worcester constant care is necessary, while a source like that of Wynberg, on the top of Table Mountain, need scarcely be a cause of much anxiety.

At Delhi the drinking water for the city is filtered partly through artificial beds, and partly through the natural sand in the bed and banks of the Jumna. In the latter case the water percolates into a series of wells, from which it is pumped into the town reservoir. Although the quality of the water is excellent, the principle of supply is not free from the grave objection that the rate of filtration is unknown, and that the system is also liable to disturbance from many causes, including varying pressure owing to changes in the volume of water in the stream, subsidence, or possibly earthquake.

Chloride of lime in the proportion of about 15 pounds to every 1,000,000 gallons of water pumped, has been found to give excellent results in destroying *Bacillus coli*. The method is now in force at Roberts' Heights.

Water-supply in Barracks.

During peace-time, both at home and abroad, the water-supply of barracks is furnished, as a rule, by municipal bodies. The supply may be either on the constant or intermittent system. In the former the service-pipes are always charged with water under pressure, so that a supply is obtainable at any hour of the day or night. In the latter system the water is cut off during certain hours, and storage on the premises which are supplied on this system is therefore necessary.

Fortunately, this mode of supply has to a great extent become a thing of the past, but may nevertheless be found in certain of our military stations.

In making an inspection of barracks, it should always be ascertained whether the water-supply is constant or other-

wise, and if there are any tanks in existence. Only recently I found open drinking-water tanks in the annexes of certain married quarters, and in the immediate vicinity of the w.c.'s. I suggested that a tap should be placed on the rising main, leaving the supply in the tanks for fire or other emergency. There was no practical difficulty in regard to the suggestion, and the divisional officer, Royal Engineers, ordered it to be carried into effect at once. As in the above case, the required alteration is usually perfectly simple, and attended by trivial expense.

At stations where the intermittent system is found to be in existence the storage tanks require constant and careful supervision. At Delhi there is an excellent supply of water, as far as purity is concerned, but unfortunately it is not on the constant system.* This is a distinct drawback, as water has consequently to be stored in a large tank in barracks, and the possibility of contamination by the horribly polluted dust blown from the native city is a danger not to be overlooked.

Needless to state, great expense was originally incurred in the construction of the present waterworks at Delhi, and yet the object of these works is, in part, defeated by the exposure of the British garrison to the dangers and inconvenience of storing water under circumstances which, even with all possible care, cannot insure against the entrance of those microbic forms which the system was intended to exclude.

The absence of water laid on to dwellings is a most serious defect in Indian sanitation, as even when an excellent supply is furnished from stand-pipes, the good effect is largely nullified by the carriage of the water in the unsavoury 'mussacks' into which it is drawn by the bhisties (Fig. 17). In the barracks of European troops buckets are widely in use. Buckets, of course, are preferable, but, unless water is laid on direct to the verandas, there is always danger of contamination. The plan of allowing water to be drawn by natives and stored in galvanized iron tubs is never free from danger.

* A possible defect in the system has already been noted on p. 236.

Medical officers in charge of troops should, in all cases, ascertain the nature of the system in existence. In India the constant system, with taps close to the rooms, might with advantage be introduced into all stations where it is by any chance possible to do so.

In some foreign stations Larymore boilers are in use in barracks. When the water can be satisfactorily stored the system is an efficient safeguard, but if the water is allowed to cool in open chatties kept in the barrack-rooms, the whole object of the process is defeated, and an unnecessary expense in plant and fuel is incurred.

Galvanized iron tanks are not altogether unobjectionable for storage purposes after boiling, as the hot water is more likely to act rapidly on the zinc than water at the ordinary temperature. Iron tanks, which have had their interiors subjected to Barff's process, would be preferable to those now in use.

The only important effect of the addition of permanganate of potash, especially when sprinkled from the hand of the conservancy orderly, is the introduction of germs into water from which they may previously have been absent.

Some of the possibilities connected with boiling, unless the procedure is scrupulously carried out, are well set forth in the Army Medical Report for 1902 :

'The water is boiled, or supposed to be boiled, in a large "dekchi," or caldron, and allowed to cool, or partially cool, therein. At this stage it may or may not be sterile as regards enteric germs. Assume it to be sterile, a "bhisti" then brings two galvanized iron buckets, and while he places one on the ground, he dips the other into the caldron and fills it with water. He then fills the other bucket in a similar way, and as the bottoms of buckets are full of chinks where dirt can rest, where there is dirt, it falls to the bottom of the water in the caldron and contaminates it. The buckets of water are then carried to water-tanks in the verandas of soldiers' bungalows and the water poured into them. These tanks, of course, are never sterilized, and in some stations are quite unprotected as regards locks on the lids. The soldier comes along in a hurry for some water

for washing purposes, and as the flow from the tap of a cistern is too slow, he raises the lid (if it is not already up) and naturally dips his basin in from above, and again the drinking supply is contaminated. Regimental authorities may order bhistis to keep their buckets clean and hang them up, and tell them never to let the buckets rest on the ground for a minute, but, short of detailing soldiers to watch every bhisti all the time he is doing his work, it is impossible to protect water in barracks. On the whole, it may be concluded that while boiling is in itself an excellent safeguard, its utility may be absolutely nullified by faulty administration.'* This state of things is fortunately disappearing.

I have no personal experience of the measure, but it seems only common sense that the installation in barracks of some effectual form of mechanical filter would, in the saving of fuel and wear and tear of plant, be cheaper than boiling, and certainly not less effectual; at any rate, it might have a fair trial.

In some stations abroad, rain water is stored in tanks for drinking and other purposes, but I must forbear to discuss a system of which I have no practical knowledge.

As in the case of collection and that of storage, already referred to, further details of distribution are found in well-known works, and need not, therefore, be recapitulated here, the preceding remarks being mainly intended to furnish examples of sanitary defects, the non-existence of which in all barracks might possibly have been otherwise assumed.

Diseases due to Water.

These morbid conditions may be conveniently classified as follows—namely, those caused by:

1. Germs.
2. Animal parasites.
3. Matters in suspension.
4. Matters in solution $\begin{cases}\text{Organic.}\\\text{Inorganic.}\end{cases}$

1. Under the first heading enteric fever, cholera, dysentery, diarrhœa, are the most important.

* Army Medical Report for 1902, p. 202.

2. Animal parasites comprise *Bilharzia hæmatobia, Ankylostoma duodenale, Filaria sanguinis hominis, Rhabdonema intestinale, Filaria dracunculus;* segments and the ova of tapeworms may also be present in water.

There are, of course, an enormous number of other forms, but these are probably the most important from a military point of view, and it may save tedious recapitulation if the practical fact is remembered that a variety of parasites may gain entrance to the human body by means of drinking

FIG. 18.—BHISTI FILLING MUSSACK FROM A STAND-PIPE.

water, and there are no preventatives safer or more generally applicable than boiling, or the use of a filter.

3. Under this heading mica demands special mention, as it is sometimes found in water, particularly in moorland districts where granite is present, and it is believed to be the cause of a form of diarrhœa common in some parts of India. It is easy to see that a substance of this nature must have an irritant effect on the intestinal mucosa.

4. Under the heading of matters in solution, organic chemical poisons are those which medical officers on service

are particularly likely to encounter. The bodies of dead horses, or of transport animals generally, often find their way into streams, and I remember, on one occasion in South Africa, finding a partially decomposed trek ox within a few feet of a spring intended for the supply of the Yeomanry column of which I was in charge. There is a mistaken idea that boiling or filtration, or both combined, will remove every form of danger connected with water. This is a dangerous delusion. Soluble organic poisons, the result of almost any form of animal or vegetable pollution, are no more to be removed by boiling or filtration than any other kinds of chemical poisons—in fact it would be just as reasonable to expect that lethal drugs with which we are well acquainted would have their nature altered by the process mentioned. Even distillation is inefficacious, and an outbreak of diarrhœa which occurred 'on board H.M. ships in the harbour of Valetta was attributed to impurities in the water distilled from the not over clean water of the grand harbour.'* Vegetable organic poisons can only rarely occur, but the possibility of their presence should be remembered.

The commonest form of inorganic poisoning is lead, although, as already indicated, this danger has probably been overestimated, except, possibly, in the case of peaty waters. In the *British Medical Journal* of March, 1904, there is a most interesting editorial, entitled 'Lead-Poisoning and Water-Supplies,' which gives a masterly précis of the conclusions arrived at by Dr. Houston in his comprehensive report published by the Local Government Board on 'Moorland Waters in Regard to their Action on Lead.' The investigation carried out proves, in the words of the editorial in question, (1) that the cause of the plumbo solvency is due to the acid in the water; (2) that the acid is formed by contact with the moist peat on the catchment ground; (3) that the formation of acid is due, at all events in part, to the presence of acid-producing bacteria in the peat itself. Two such organisms, 'designated peat bacteria O and peat bacteria Q, have been isolated, and have been

* Parkes.

found to be capable, when introduced into sterile peat decoction, of rendering the liquid acid and plumbo solvent in character.'

As regards remedies, 'Dr. Houston is inclined to believe that the best method is a combination of ordinary sand filtration, with the addition of some neutralizing material to the filter; for example, a thin coating of lime in the surface of the sand, with lime underneath the sand, and the subsequent addition of a trace of sodium carbonate to the neutral filtered fluid.'

Highly oxygenated waters have an erosive action on lead, particularly in new pipes. Acid waters and neutral distilled waters, also waters containing nitrates, nitrites, chlorides, or organic matters, all act as solvents of this metal; polluted shallow well water has the same action, probably in virtue of the above chemical substances. Hard waters which contain lime or magnesia are relatively safe, as they form an insoluble carbonate or sulphate of lead in the interior of the pipes, and further action is thus prevented.

It is important to remember the plumbo solvency of water may vary greatly—for instance, during dry weather it may not be detected at all, for the simple reason that the bulk of the water comes from underground; while heavy rain after drought carries with it an accumulation of material possessing remarkable powers of the kind in question.

Zinc, copper, iron, or tin may be present in water. A galvanized iron bucket which has fallen into a well and is allowed to remain there may produce symptoms of zinc-poisoning. The last source of sickness must, however, be very rare. Distilled waters are very prone to act on metals, notably on zinc, iron, or copper. This fact has a very practical application as affecting means of storage. The effect on lead has already been noted.

In cases of doubt the presence of the above metals may be detected by well-known means.

Natural metallic impurities are often present in drinking water, but, in spite of the importance of the subject, it is

impossible to frame adequate precautions against a danger which could only be dealt with according to circumstances.

Although not generally classed as an impurity, extreme hardness of water may be conveniently considered at present. Hardness is of two kinds, respectively known as permanent and removable. The first is caused by the presence of the bicarbonate of lime alone or in conjunction with bicarbonate of magnesia, and, as suggested by its name, may be removed by appropriate means.

By boiling the water the carbonic acid, which holds the bicarbonates in solution, is driven off, and only the insoluble carbonates remains, thus :

$$\underset{\text{Calcium bicarbonate.}}{CaH_2(CO_3)_2} = \underset{\text{Calcium carbonate.}}{CaCO_3} + \underset{\text{Carbonic acid.}}{CO_2} + \underset{\text{Water.}}{H_2O}.$$

In the case of the bicarbonate of magnesia, a certain amount of the carbonate redissolves on cooling.

The permanent hardness is caused by the presence of calcium and magnesium sulphates and chlorides, and is not affected by boiling.

In choosing camping-grounds the hardness, or otherwise, of the water is a question occasionally overlooked. Hard water will not readily lather, as it forms insoluble calcium and magnesium oleate with the soap; it thus conduces to uncleanliness, and consequently to sickness, among the men. It is also badly suited for cooking, and the food is, therefore, apt to be unappetizing. Lastly, there is the constipating effect of chalk (calcium carbonate), and the laxative effect of calcium and magnesium sulphates, to be reckoned with.

In the case cited above of Garrison Gorse and Bourley, a slight change in the location of the troops would have made an enormous difference in the water-supply, and therefore, in inspecting proposed camping-grounds, it should always be ascertained whether, in case of a supply of hard water, an alternative site free from this objection is available.

Water on Service.

Water, on service, is derived from a variety of sources which it is utterly impossible to enumerate, and how far these sources are dangerous or not must often depend on conditions which cannot possibly be foreseen, and which have to be reckoned with as they occur. Common sense and a knowledge of the principles of sanitation must be the main guides for arriving at accurate conclusions. If there is one thing more certain than another in connection with water on service, it is the absolute futility of trying to carry out any analysis in the field. 'A little knowledge is a dangerous thing,' and this old saying has received recent exemplification of a striking nature in the recommendations of certain well-meaning persons whose knowledge was not commensurate with the excellence of their intentions, and who, according to their published statements, seem to consider it only reasonable that hostilities should be suspended until all water-supplies for troops in the field have been submitted to the most recent methods of scientific investigation—an excellent proposal from a sanitary point of view, but which, if reduced to practice, might, at times be prejudicial to military success.

The purification of water, during peace, as already indicated, will, of course, depend on well-known sanitary principles and on local exigencies. On active service the requirements of troops may vary from day to day, and the practical application of sanitary rules must often remain in abeyance.

On service it is best, with scarcely any reservations, to look on all water as dangerous, and to act accordingly. There are three main principles which may be adopted in the purification of water-supplies—viz., purification by chemicals, by heat, and by filtration.

Purification by Chemicals.

This principle has many forms of practical application. One of the best known is that of Vaillard,* who proposes to sterilize water by means of iodine. The process is thus described in the *Journal of the R.A.M.C.* for July, 1903 :

'To obtain the iodine in a free state he decomposes iodate of sodium with tartaric acid, and then dissolves it in an excess of iodide of potash. To make the method of practical application the various reagents are compressed into differently coloured tabloids in accordance with the following formula :

'No. 1. Blue tabloids { Iodide of potassium, 10 grammes.
Iodate of sodium, 1·56 grammes.
Methylene blue, a sufficiency.

'Divide into 100 tabloids, each weighing 0·1156 gramme.

'No. 2. Red tabloids { Tartaric acid, 10 grammes.
Fuchsin, a sufficiency.

'Divide into 100 tabloids, each weighing 0·1 gramme.

'The simultaneous solution of a red and blue tabloid in a litre of water sets free 0·06 gramme of iodine, leaving 0·0346 gramme of iodide of potassium and small quantities of tartrates of potash and soda in solution.

'When the liberated iodine has acted for ten minutes, one neutralizes it by adding and dissolving in the water a third tabloid, white in colour and containing 0·116 gramme of hyposulphite of soda. All this free iodine is at once combined with the soda into iodide of sodium.

'The water is now found to have a normal appearance, and to be free from any taste or smell.

'This chemical purification, or rather sterilization, of the water can be carried out in any metal vessel, without detriment. In the case of waters heavily laden with suspended matters, a preliminary clarification is desirable. This method is similar in its chemistry to Schumburg's bromine procedure. We have not had any opportunity of testing its efficiency,

* *Archives de Médecine et de Pharmacie Militaire*, No. 7, 1902.

but, according to Vaillard, sterilization of water is secured in ten minutes.'

This extract has been given at length, as furnishing an example of a method which is, in most cases, incompatible with active hostilities. Like other modes of chemical purification, it entails increase of transport, increased labour of administration, and delay in execution; and these are most serious objections to such schemes, even assuming the results are such as the originators claim.

There is also a proposal to purify water by means of copper sulphate; 1 in 1,000 is stated to kill typhoid and colon bacilli in an hour, and 1 in 10,000 is stated to kill the former, but not the latter. It is also stated that water kept in a clean copper vessel is freed from *B. coli* or *B. typhosus* in twenty-four hours.* It has likewise been suggested to purify water by ozone, but the information at present available concerning this process is somewhat meagre. These schemes need further elucidation.

There is no satisfactory evidence as to any lethal effect of chemical methods on the parasitic forms, to the inroads of which men are exposed by drinking impure water; and even if developed forms are destroyed, it is more than likely that ova escape. This objection does not apply to sterilization by heat or filtration. Up to the present our attention has been concentrated on the presence of micro-organisms in water, to the comparative exclusion of other dangers; and the latter, in consequence, run some risk of being overlooked.

Heat.

There is no doubt that the boiling of water is, when it can be satisfactorily carried out, the most effectual safeguard we possess against the introduction into the body of living agencies of disease.

Unfortunately, the process is not always feasible on service. Boiling in camp-kettles is generally a hopeless failure. Fuel is not always to be obtained; the camp-kettles are required for other purposes; the extra labour is a fruitful source of

* *R.A.M.C. Journal*, March, 1904.

exasperation to the men ; the water is frequently contaminated before it is cool ; and, lastly, the necessary delay is often an insuperable obstacle to success. When special apparatus is employed, certain of these objections do not apply. Of all apparatus, the Waterhouse-Forbes sterilizer, which originally made its appearance in the United States Army, seems to be the best, although doubts have been thrown on its efficiency, as seen from the following extract from the Annual Report of the Surgeon-General at Washington :

'The custom of boiling all drinking water in the Philippine Islands is kept up, and there appears to be a loss of confidence in the Waterhouse-Forbes sterilizer, with much difference of opinion as to its merits. It is hoped that a series of experiments made on the spot may demonstrate the exact value of the apparatus of which so much was expected.'*

The following is an extract from the official description of the apparatus :

'In order to easily illustrate the action of this principle, reference will be made to the purely diagrammatic drawing, Fig. 19, in which 1 shows a water-tank with a pipe, 2, through which water enters and is allowed to fill the tank up to the water-level, X, and no higher, as it is restrained by the float-operated valve shown in the tank. The water to be treated passes from the tank, No. 1, down through the pipe, 3, into the compartment, 4, of the heat exchange. Rising in the compartment, 4, the water enters the heater, 5, and rises in the pipe, 6, to the level, X. Heat is applied to the heater, 5, by means of the flame, 7, which causes the water in 5 to boil over through the pipe, 6, into the top of the compartment, 8, of the heat exchange. When compartment 8 has become filled, the water runs off through the orifice, 11, of pipe 10. While passing down through the compartment 8 the heat of the water, which is boiling hot, is transferred by conduction through the partition or diaphragm, 9, to the cold water passing up through compartment 4, so that the water which

* Report of the Surgeon-General United States Army for the Fiscal Year ending June 30, 1903, p. 43.

is boiling in 5 passes out of the apparatus nearly as cold as that entering the apparatus, while the cold water entering the apparatus becomes heated as it passes towards the heater, 5, and reaches the heater in a very hot condition, and nearly at the boiling-point. Therefore, the only heat which can be supplied is that necessary to bring the already heated water entering 5 to the boiling-point, and cause it to rise above the normal level, X, and boil over through the pipe, 6, and so pass on through the remainder of the apparatus to the discharge outlet, 11. It will be observed, therefore, that but little fuel is required to operate this apparatus, for the reason

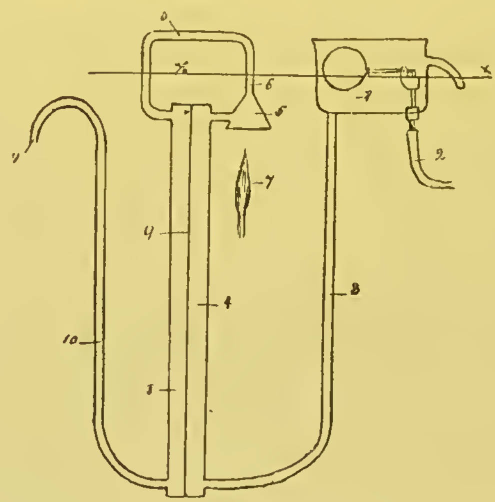


FIG. 19.—DIAGRAM OF WATERHOUSE FORBES WATER STERILIZER.
From Annual Report for Fiscal Year ending 1899 of Surgeon-General United States Army.

that the heat is conserved and used over and over again; whereas by the ordinary process of boiling water and allowing it to cool off naturally, all the heat which is required for raising the temperature of the water to the boiling-point is thrown away. For example, if water is discharged from the Waterhouse-Forbes apparatus 5° higher in temperature than it had on entering the apparatus, but 5 units of heat are lost for every pound of water treated, whereas by the ordinary method, assuming the water to have an original temperature of 62° F., it must be raised to 212° F. to reach the boiling-point, and each pound of water treated, therefore, must have

150 units of heat put into it, and all this is lost in cooling. It is apparent, therefore, that the Waterhouse-Forbes system is thirty times more economical in fuel.'*

A form of water sterilizer known as the Griffith's sterilizer has made its appearance in recent years. In general principle it resembles the Forbes-Waterhouse water sterilizer, but differs from the latter in the fact that the water is not raised to the boiling-point, an important economy being thereby effected. The working is most ingenious, and reflects great credit on the inventor; it would probably be most effective in standing camps, but whether it would stand the wear and tear of constant movement during active service is a different matter.

Before heating water for drinking purposes, preliminary clarification is often necessary; this may be effected by some form of improvised filter, or by the addition of alum. The latter acts on alkalies present in the water and forms a precipitate of aluminium hydrate—$Al_2(OH)_6$—which carries down with it suspended material. Alum should never be regarded as an effectual means of purifying water; it is merely an adjunct, and to look on it in any other light is a serious mistake, and may end in disaster.

More extensive trials are required before an absolute opinion can be expressed as to the question of relative merit. Delay, of course, is a serious objection to any kind of apparatus, but in standing camps this need not be considered, as the question of time is not one of vital importance. With mobile columns the quantity of water which is carried is limited, and there is often no time to resort to any lengthy methods when the original supply has run out. Under these circumstances other means are required.

Filtration.

Of the many filters which have been devised for service in the field, the Berkefeld filter is the one which has had the

* Annual Report of Surgeon-General United States Army for Fiscal Year ending June, 1899, p. 218.

most extensive trial. It is handy, easily worked, and easily sterilized.

Its disadvantages are due less to itself than to an occasional inadequate supply of candles. The candles are easily broken, and this is no doubt a drawback ; but the amount of space which they occupy is not excessive, and a liberal supply would not seriously embarrass the transport arrangements. A more serious fault than the fragile nature of the candles is the fact that the latter need sterilization three times a week, and this can only be effected by means of boiling water. It has been stated by a board of medical officers of the United States Army that repeated sterilization of the candles of the filter induces some change in the material of which they are composed, and allows bacteria to appear in the filtrate.* Judging from personal observation, I believe this to be a fact.

Sterilization is necessary from the fact that bacilli can grow through the substance of the candles, so that, if the above measure is omitted, a supply of pure water may, after filtration, contain germs from which it was previously free. If possible, water should undergo a preliminary clarification before being passed through a Berkefeld filter, as the candles became rapidly choked, and the process has constantly to be interrupted for the purpose of removing the deposit. Clarification can be effected by alum, straining through a clean cloth, or, when possible, by a Maignen's filter. Great care should be taken that the candles are not flawed, as this defect would allow the direct passage of micro-organisms with the filtered water. The Berkefeld filter is certainly far from perfect, and at present is commonly considered merely a relic of the past ; but with ordinary care, and with ordinary liberality on the part of the authorities in the supply of candles, its somewhat tarnished reputation might be revived.

The Pasteur-Chamberland filter, excellent as it is in many respects, was reported on as being too slow in delivery for

* Annual Report of Surgeon-General United States Army for the Fiscal Year ending June, 1899, p. 217.

use in the field,* and in South Africa the trade failed to supply a sufficient number for general use.†

A service water-cart fitted with Slack and Brownlow filters is the means now widely adopted in our army.

A pump is attached to each side of the cart, and water is pumped from the source of supply, through a hose carried for the purpose, into the body of the cart. It passes *en route* through clarifying sponges, the final purification being

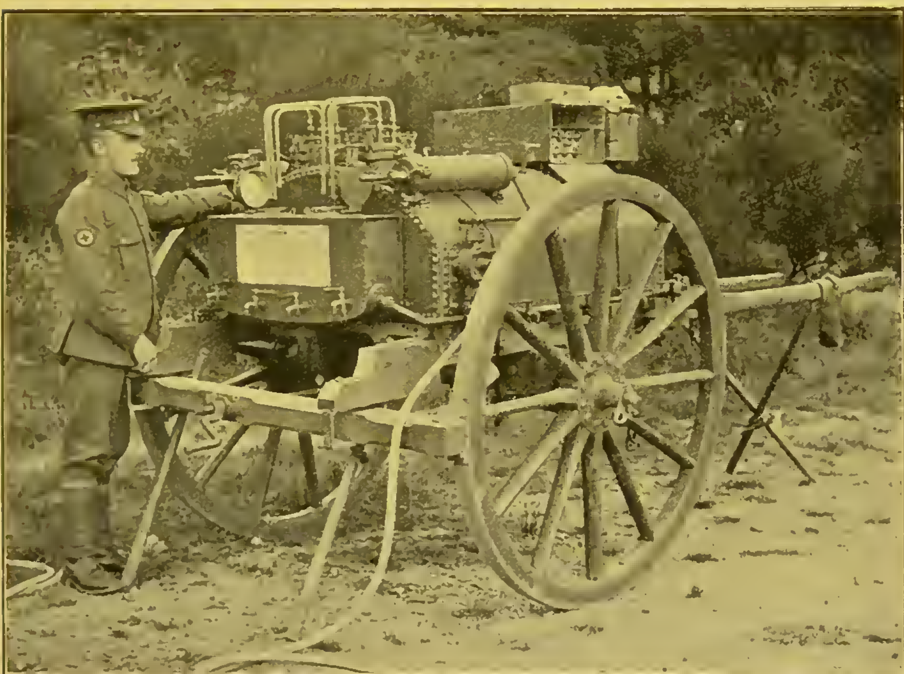


FIG. 20.—SERVICE WATER-CART.

Photo by Sergeant Gregson, R.A.M.C.

effected by passage through the Slack and Brownlow filter candles, of which latter there are eight, arranged in two batteries of four candles each. Water can be pumped through the candles either from the body of the cart or else direct from the source of supply. The actual working details can only be learned by experience. The carts had

* See Army Medical Reports, vol. xlvii., Appendix III.

† See Report of Royal Commission on South African War, Question 3,790.

one of their trials in the Southern Command's manœuvres of 1907. I was acting as Sanitary Officer and Staff Officer to the Principal Medical Officer of the Northern Force, and I took the opportunity to test one of the carts by filling it from a stream in the neighbourhood of our camp, and sending a sample of the filtered water and one of the raw water to the acting special sanitary officer at Devonport, Major R. J. Blackham. Major Blackham's report was satisfactory, and his opinion was fully corroborated by the examination of other samples ; but further examination revealed the fact that the pump failed to act in frosty weather, and that after a short period of use—including the necessary sterilization of the candles—the filtered water was far from being germ-free. It was observed that there was a distinct increase of the chlorides after filtration, and furthermore that the amount varied according to the candle, indicating that the composition of the candles was neither absolutely stable nor absolutely constant. In spite of these defects, I believe the cart is so far admirable in that it is by far the nearest approach we have made to the solution of the water question. What is needed is a working rule as to the length of life of the candles, and the supply determined according to the decision arrived at. With a liberal supply of candles, it is likely that the method will effect all that can reasonably be expected.

Great care should be exercised in the storage of water in camps if the above means are not available. One or more clean water-carts should be kept exclusively for this purpose. The lids should fit accurately ; the interiors should occasionally be washed out with boiling water, and they should be kept well away from the transport or horse lines, and outside the immediate precincts of the camp. It would be well if the lids were padlocked and the key placed in charge of a sentry, the key being handed over in the ordinary way when the relief is carried out. The sentry should be responsible for prevention of waste, for once the water-carts are run dry the men will drink anywhere. Separate carts should be kept for bringing water to camp ; after boiling or

filtration the water should be placed in the storage-carts, and drawn from them as required. It cannot be sufficiently insisted on that water of a doubtful nature should never be introduced into the storage-carts, as even minute traces of it might pollute subsequent supplies, and so become a source of widely-spread danger. It is to guard against the consequences of this possibility that frequent washing out with boiling water has been recommended. In practice this would be very difficult to do thoroughly, but it certainly ought to be attempted; the most effectual measure would be steaming, but in the field it would generally be impossible. The water-carts commonly in use are constructed of galvanized iron; they are rectangular in shape; and the taps not being flush with the bottoms, it is difficult to get rid of sediment. It would be a great improvement if the water-carts were circular and capable of receiving a rotatory movement, like the old-fashioned churn. Galvanized iron is objectionable, as it has been known, on occasions, to yield zinc to the water. The danger is greatest with rain water or distilled water, or, in fact, any kind of soft water which is in use.

A proposal to expend large sums of public money on heat sterilization, and then to store the sterilized water in an open canvas trough, would not require mention if it were not that an arrangement not far removed from the above was actually in existence at certain militia camps during the trainings of 1907. The manner in which the last-named conception was materialized took the form of open galvanized iron tanks from which supplies were obtained by dipping, and which, like the canvas trough, were placed at a height suitable for the convenience of a drunken man anxious to obey the calls of Nature. The tanks were abolished on my urgent representation, and their removal was probably accelerated by an outbreak of enteric fever in the 3rd Devon Militia at Filleigh. I was called upon to investigate the outbreak, and, although I do not believe that its advent was caused by the tanks, there is no reasonable doubt as to the disease having spread by this means.

Water-carts when issued from store are not always above suspicion, and I have found an originally pure supply teeming with *B. coli* when drawn from the carts in use. This is a serious matter, and calls for some means of purification before the carts are issued to the troops. It is a reasonably good plan to wash the carts out with a solution of permanganate of potash. It must not be imagined for a moment that the permanganate will insure safety, but what it will do is to indicate the presence of organic dirt, by a change in colour from pink to brown. As long as the pink colour is retained, when the solution of permanganate leaves the cart, the process of cleansing can be considered as reasonably satisfactory, but it by no means follows that dangerous germs are *certainly* destroyed. Permanganate can be used as affording an indication of danger, but not as a means of procuring safety. The only really effectual way of cleaning water-carts is by means of steam.

Men's water-bottles are often in a most filthy condition. They occasionally contain semi-decomposed tea-leaves. Like the water-carts, the water-bottles should be frequently scalded with boiling water, and for the same reason.

Major Norman Faichnie, R.A.M.C., has designed a form of water-bottle described in the *Journal of the R.A.M.C.* for March, 1907.

By an ingenious contrivance the top of the bottle can be removed and the interior sterilized without difficulty; the bottle is made of aluminium, thus following the principle of using the lightest metal possible, and by means of a handle it can be placed on or removed from a fire without difficulty. Major Faichnie can be heartily congratulated on his idea; although, of course, experience may reveal the necessity for some modifications.

In concluding this chapter I have thought it well to tabulate the dangers in connection with impure water, and to indicate by means of brackets how each may be avoided by means of purification which have been discussed.

<table>
<tr><td>Germs</td><td rowspan="3">Filtration</td><td rowspan="2">Heat</td><td>Chemicals.</td></tr>
<tr><td>Animal Parasites</td><td></td></tr>
<tr><td>Matters in Suspension</td><td></td><td></td></tr>
<tr><td>Matters in Solution</td><td colspan="3">Organic.
Inorganic.</td></tr>
</table>

It will be seen that filtration removes three classes of impurity, heat removes two, and chemicals remove one, while matters in solution remain unaffected.

The above table, it must be added, requires certain amplification in regard to the organic matters in solution. It is true that substances of the kind can be oxidized, and therefore destroyed by permanganate of potash, in virtue of the fact that the latter readily gives up its oxygen in the presence of oxidizable material, with the production of manganese dioxide. The actual splitting-up of the compound is shown in the following equation:

$$4KMnO_4 + 2H_2O = 4MnO_2 + 4KHO + 3O_2.$$

The Candy filter would, in like manner, by means of compressed air and polarite, effect oxidation of organic matter.

In the first case, however, the amount of permanganate added would, by the production of a brown colour due to MnO_2, so far alter the appearance of the water as to render the latter undrinkable, besides which water requiring purification by such means would probably contain germs which the permanganate would not affect, except in prohibitive quantities.

In the second case—*i.e.*, the Candy filter—we do not know that the means in question would be generally applicable to military service.

For practical purposes, therefore, the conclusion already expressed must be considered to hold good.

General Conclusions and Recapitulation.

1. With few exceptions all water on service should be considered as dangerous.
2. Spring water is no guarantee of safety.

3. The sparkling appearance of some spring water and shallow well water is dangerously deceptive.

4. Poisons in solution are not affected by boiling or filtration.

5. Satisfactory analysis on the field is, as a rule, incompatible with military exigencies.

6. Attempts at sterilization with chemicals are undesirable.

7. Heat, when applicable, is the most effectual means of sterilization.

8. The Slack and Brownlow filter should give satisfactory results if the supply of candles is sufficient.

9. The candles should be sterilized as directed—on service this is apt to be forgotten.

10. Certain water-carts should be reserved for storage only.

11. Men's water-bottles require constant attention, and should be frequently washed out with boiling water.

12. The application of steam is the proper method of cleansing water-carts.

CHAPTER XV

AIR

AIR consists of the gases nitrogen and oxygen in the following proportions—viz., four-fifths of nitrogen and one-fifth of oxygen. The mixture is a mechanical one, the gases not being in actual combination, a fact which has been amply proved by means which it is unnecessary to consider at present.

The use of the oxygen is to combine in our bodies with the food, and so to maintain the heat of the animal organism, and to furnish the energy essential for the functions of life. To attain this purpose, oxygen is drawn into the lungs in the act of inspiration, and is carried by the red corpuscles of the blood through the various tissues, in which latter the combination named above takes place.

If the air consisted of oxygen only, the union would be correspondingly intensified; in fact, not only would the food be oxidized, but the tissues as well, and the process would continue at such a rate that even the most enormous quantities of food would be unable to protect the body itself from being consumed; ordinary fires would assume the dimensions of conflagrations, and life as we know it would be impossible. Nitrogen prevents such results by its diluting action, but otherwise it is an inert gas, having no effect of its own.

Carbonic acid is commonly present in air in the proportion of 0·4 per 1,000; and there are also various impurities, but these need not now detain us.

We really live at the bottom of an ocean of air, and the lower layers are naturally pressed down by those above them ; it follows that, the higher we ascend, the less the quantity of air, until finally we reach a distance at which there is no air at all.

Air has other functions besides that of supplying oxygen for our use : it is a conductor of sound ; it breaks up the sunlight, or, to use a technical term, it 'diffuses' the sunlight ; lastly, by means of the watery vapour it contains, it protects us against the heat of the sun (see Climate).

If there were no air, the sides of all objects turned to the sun would be in a blinding glare, and the opposite sides plunged in inky darkness ; even the most massive structures would crumble into ruins before the terrific heat ; and a weird and ghastly silence would prevail—in fact, the world would be impossible as a place of residence.

The sources from which the impurities in the atmosphere are derived may, for military purposes, be roughly classified as arising from (1) the products of respiration ; (2) the products of combustion ; (3) the soil. Impurities from industrial sources need not be considered.

1. Respiratory.

Respiration is divided into two acts—namely, inspiration and expiration. In the former the chest walls expand, with a consequent inrush of atmospheric air ; in the latter the same structures contract, with consequent expulsion of contained gases. The act of inspiration furnishes the body with oxygen, which, being taken up by the blood in the lungs, is conveyed to the tissues for the continuance of life and energy. Expiration, on the other hand, expels from the body the gaseous products of animal life, the accumulation of which within the organism would lead to disastrous results. In general terms, the air in the lungs contains about 16 per cent. of oxygen, and about 4·5 per cent. of carbonic acid. The constant production of carbonic acid would, but for certain natural agencies, ultimately end in the extermination, not only of the human

race, but of animal forms generally. Fortunately, the vegetable world saves us from extinction by its power of fixing the carbon of the carbonic acid and liberating the oxygen for our use.

The expired air contains other products of a deleterious nature besides carbonic acid, but the nature of these need not be considered here. As it would be a matter of great complexity to attempt an accurate analysis of the products of respiration, the amount of carbonic acid in air is taken as an index of the extent of impurity present. For practical purposes the proportion of carbonic acid in atmospheric air may be estimated at about 0·4 per 1,000 cubic feet of air. The limit consistent with the maintenance of health is placed, according to the conclusions arrived at by the late Professor de Chaumont, at 0·6 per 1,000 cubic feet of air. 0·2 cubic foot of CO_2 can therefore be added to every 1,000 cubic feet of air before the above limit is reached.

When at rest an adult is estimated to give off in one hour about 0·6 cubic foot of CO_2, when engaged in light work 0·9 cubic foot of CO_2, and during very hard work possibly as much as 1·8 cubic feet of the same. Soldiers in their barrack-rooms may be considered at rest.

From the above facts it is a fairly easy matter to estimate the quantity of air required per hour by a given number of persons in a room the dimensions of which are known. As it is a question on which a medical officer might possibly be called upon to express an opinion, and as the formula which gives the required information is very simple, it may not be out of place to set forth certain explanatory figures. It should be explained, however, that the quantities calculated are not those allowed according to regulations.

The formula, I should state, is borrowed from Parkes and Kenwood's admirable textbook, 'Hygiene and Public Health':

If D represents the delivery of fresh air in cubic feet, E the amount of CO_2 exhaled, and R the respiratory impurity which is to be allowed per cubic foot of air, then—

$$\frac{E}{D} = R, \text{ or } \frac{E}{R} = D.$$

Example 1.—If six men occupy a barrack-room of 10,000 cubic feet, what amount of fresh air must be allowed per hour in order that the CO_2 may not exceed 0·6 cubic foot per 1,000 of air?

Six men resting will collectively produce in one hour 3·6 cubic feet CO_2, since each man individually produces 0·6 cubic foot CO_2; therefore $\frac{E}{R} = \frac{3\cdot6}{0\cdot0002} = 18{,}000$ cubic feet. This includes the 10,000 cubic feet of air which the room contains, and to which 8,000 cubic feet of air must be added. As there are six men in the room, each man must have, consequently, 3,000 cubic feet per hour. There are already 10,000 cubic feet of air in the room, so that the additional 8,000 cubic feet will suffice for the first hour, after which time the full amount of 18,000 will be required.

Example 2.—In a guard-room of 5,000 cubic feet five men are on guard; what proportion of CO_2 will there be in the air at the end of an hour?

Here the formula is slightly different. Five men will collectively produce in an hour 3 cubic feet of CO_2; therefore $\frac{E}{D} = \frac{3}{5{,}000} = 0\cdot0006$, or a respiratory impurity of 0·6 of CO_2 per 1,000 cubic feet of air, which, added to the amount of CO_2 per 1,000 cubic feet of air, already present, will bring the total to $0\cdot6 + 0\cdot4 = 1$ cubic foot CO_2 per 1,000 cubic feet of air.

Example 3.—How often should the air be renewed every hour in cells of 600 cubic feet each, in order that the CO_2 may not exceed 0·6 cubic feet per 1,000 of air, in any occupied cell?

Here the amount of CO_2 exhaled by one prisoner will be 0·6 cubic foot per hour, and the total CO_2 to be allowed is 0·6 cubic foot per 1,000 of air. 0·0002 of CO_2 per cubic foot of air can consequently be added in the form of respiratory impurity to the 0·0004 already present; therefore $\frac{E}{R} = \frac{0\cdot6}{0\cdot0002} = 3{,}000$ cubic feet of air required. As the cell only measures 600 cubic feet, the air would have to be

changed five times an hour. This is oftener than most people could stand with comfort or safety. It is assumed that each prisoner is at rest, or, at any rate, not engaged in any arduous exertion.

In the case of Example 2 it is, of course, clear that no guard-room is hermetically sealed, so that the calculation would only be approximate, and an allowance would have to be made for door and windows.

In actual practice, physical examination by the senses for the purposes of daily routine in the service, is of more value than results arrived at by calculation. There are, however, cases of official inquiry in which exactitude is essential, and under these circumstances a knowledge of a simple and readily applicable formula would certainly be useful. It may here be explained that during winter months at home a change of the total quantity of air in a room oftener than three times in one hour is likely to be accompanied by draughts and general discomfort, and the following is an example of a calculation which may be of service in arriving at the amount of cubic space requisite for the avoidance of the above disadvantages :

Example 4.—What number of men can be accommodated in a room of 18,000 cubic feet in order that the CO_2 may not exceed 0·6 cubic foot per 1,000 of air, the air being changed three times in one hour ?

The total discharge of air in an hour, if the amount originally in the room is included, will be 54,000 cubic feet, and the total amount of CO_2 to be allowed is 32·4 cubic feet. Of this, one-third only will have been exhaled, namely, 10·8 cubic feet, and as one man at rest produces in an hour 0·6 of CO_2, and as $\frac{10 \cdot 8}{0 \cdot 6} = 18$, this number of men will produce 10·8 cubic feet of CO_2.

The latter number can therefore be accommodated, each having 1,000 cubic feet of space.

As a matter of actual fact, the allowance of air to which men are entitled by regulation is shown in the table on next page. The scale given, as contrasted with that authorized

by the Local Government Board for workrooms and common lodging-houses, is not a bad allowance, and is excellent as compared with the space allotted to each scholar in public schools.

Station	Permanent Buildings.		Wooden Huts.	
	Floor Space.	Cubic Space.	Floor Space.	Cubic Space.
HOME STATIONS.	Square Feet.	Cubic Feet.	Square Feet.	Cubic Feet.
Great Britain and Ireland and Channel Islands	60 57	600 600	60 50	600 500
STATIONS ABROAD.				
Scale 'A' (Sub-Tropical).				
Bermuda, Cape of Good Hope, Cyprus, Gibraltar, Jamaica (Newcastle and Up Park Camp), Malta, Mauritius (Cure Pipe and Phœnix), Sierra Leone (Mount Aureol and Tower Hill), Egypt, Hong Kong (except Victoria), Natal	60 60	720 630	60 50	720 500
Scale 'B' (Tropical).				
Ceylon, Hong Kong (Victoria), Jamaica (Port Royal), Mauritius (Port Louis), Sierra Leone (King Town), Singapore	80 80	1,000 1,000	75 75	850 850

The lower row of figures belonging to each of the above classes indicates the old scale.

(Army Medical Report for 1908, p. 44.)

In 1902 a Departmental Committee, appointed to consider the proportion of CO_2 per 10,000 volumes of air to be allowed to factory operatives, recommended that a 'maximum legal limit of 12 volumes by day and 20 volumes by night, with gas burning, should be established for factories and workshops generally.' This recommendation was condemned by the Council of the Incorporated Society of Medical Officers of Health, as well as by two members of a former committee—

viz., Sir H. Roscoe and Dr. A. Ransome.* It is generally held that not more than 9 volumes per 10,000 should be allowed.

The discussion which arose is of interest as showing the contrast which exists in one vital matter of sanitation between the soldier and the civilian belonging to a class from which the army is largely recruited. In the case of the former, when allowance is made for barrack furniture, the allotted space of 600 cubic feet must, when the rooms are full, be materially reduced; and when the ventilators are closed at night, as is often the case in the winter, the proportion of CO_2 in the air must be greatly in excess of De Chaumont's limit. As a matter of fact, however, barrack-rooms rarely, if ever, contain their full complement of men. A varying number are constantly absent on guard or picket, or else in hospital, or on furlough.

Windows are opened after reveille, and a safeguard against their unauthorized closure is found in frequent inspections, and in the presence of non-commissioned officers in the rooms. During the day the usual parades and other work reduce the average number of men in the rooms to an extent which can scarcely coexist with the presence of CO_2 in excess of that which is generally considered to be the permissible maximum. Thus it happens that whatever proportion of CO_2 the soldier inhales over and above that which is held to be consistent with health, such inhalation only takes place, as a broad rule, during the hours of sleep.

The case of the civilian factory operative is widely different. In 1897 a Home Office Committee recommended that the CO_2 in humified weaving-sheds and other like places should not exceed 9 volumes per 10,000 of air. [As the specimens of air were to be taken when gas was not burning, the CO_2 present would presumably be the product of respiration, plus what is normally found in the general atmosphere.] This standard has been in force for several years, and is stated to be satisfactory. The proportion of CO_2 is, however, half as much again as that laid down by De Chaumont.

* *Public Health*, October, 1904.

The civilian operative is therefore called upon to spend by far the greater proportion of his waking hours in an atmosphere which, even under favourable conditions, is possessed of a degree of impurity to which the soldier is practically never exposed, except during the hours of sleep in the coldest season of the year.

The impurities which the civilian inhales during sleep in the working-class buildings of a city are probably beyond the average imagination.

It is true that doubts have been thrown on the deleterious effects of expired air by no less an authority than Dr. J. S. Haldane of Oxford. In his presidential address in the section of State Medicine at the annual meeting of the British Medical Association in 1904, he mentioned experiments made by himself to throw light on this question. Animals were injected with 'enormous doses' of the water condensed from expired air. 'The effects were, however, only those of distilled water.'

These experiments, though interesting, are nevertheless opposed in their results to practical experience, and we are therefore still justified in including a pure atmosphere amongst the many beneficial influences—such as food, clothing, healthy occupation—which account for the rapid physical improvement of the average recruit.

In general terms there are two opposing views in regard to the evil effects of overcrowding. On the one hand, there are the views of Brown-Séquard and D'Arsonval, observers who advanced the opinion that the expired air contains a volatile poison, and they attempted to prove their contention by injecting into rabbits the liquid condensed from the above; fatal results rapidly followed, and they considered that their theory was therefore correct. On the other hand, Lehmann and Jessen carried out a similar inquiry with entirely different results, the rabbits experimented on showing no untoward symptoms of any kind; the conclusions consequently arrived at in this case were practically the same as those of Haldane, already referred to. Those who are opposed, on the strength of the last-named experiments, to

the idea of a volatile poison, believe that the results of overcrowding are due to a combined deficiency of oxygen and excess of carbonic acid, or else, according to Weir, Bergey, Mitchell, and Billings, to the existence of high temperature and foul smells.

Admitting the necessity for a pure and sufficient air-supply, a practical point for the military medical officer to remember is that the ill effects of the opposite state of affairs may not themselves be immediately apparent, but the general state of health is none the less lowered and efficiency consequently impaired. When I was Sanitary Officer at Devonport, I remember that my recommendations concerning the defective ventilation of certain buildings were not complied with, on the ground that 'no evil effects could be traced.' This is an illogical attitude, and in cases of the kind it is fair to assume as absolutely true that which cannot be immediately demonstrated. The opinions in this connection of Dr. Lachaud, member of the French Army Commission, are of interest, although happily the conditions to which he refers are greatly modified in our army :

'Entrez la nuit dans ces chambres et vous serez pris à la gorge par une odeur infecte qui ferait reculer le plus intrépide si l'habitude, seconde nature, ne venait donner à l'occupant la facilité de pouvoir surmonter le dégoût qu'elle inspire. Cette odeur étrange, mélange des émanations humaines et de celles des cuirs de toute espèce continus dans le fourniment, doit certainement avoir un effet désastreux sur la santé des hommes. Ce doit être, pour ceux qui habitent la chambrée, un poison lent mais agissant sûrement, un facteur certain qui permet, par ses effets généraux, l'évolution d'un germe épidémique quelconque.

'La respiration d'un homme de 20 ans contient des ptomaïnes qui, unies à l'odeur que fait naître une propreté insuffisante, doivent, par une intoxication lente et prolongée, avoir pour influence de diminuer la résistance physique des surmenés et des faibles qui existent en trop grand nombre dans la caserne.

'Personne n'ignore que le surnombre dans une chambre

est dangereux à cause des inconvénients que fait naître cette intoxication lente ; mais, au lieu d'essayer de diminuer la population de la chambre, on ne fait, au contraire, que l'augmenter pour créer, en empilant de plus en plus les hommes, des réfectoires qui manquent, des ateliers et des magasins de compagnie qui font défaut, et cela sans faire les constructions nécessaires, en prenant simplement les chambres que l'on a fait évacuer par les hommes.' *

In arriving at an estimate of the number of men which can safely be accommodated in any given room, it is not enough to calculate merely for cubic space. The products of respiration are not readily diffusible; they rise in virtue of their comparatively high temperature and consequent loss of weight, but sink to a low level as they lose heat and gain weight, so that mere height in any given case would be an inefficient substitute for floor-space, and for this reason any height above 10 feet should be disregarded in calculating air-space. In the United States Army the question does not appear to be completely settled.

Overcrowding and consequent pollution of air is associated with a variety of diseases, amongst which phthisis occupies a prominent place. Before due regard was paid to questions of sanitation the disease was prevalent in both army and navy, and, in fact, as a broad rule, in all crowded communities.

Pneumonia is also causally associated with the same condition. I have seen this disease break out on a crowded transport bound for the Cape. The first case occurred after at least ten days at sea, and when there had been practically no communication with the shore since our embarkation. The evidence clearly goes to prove that the mischief must have begun on board, and as there were no cases amongst the officers, who were placed under far better sanitary surroundings than the men, it is fair to assume the probability of the outbreak having arisen from causes associated with the conditions under which the latter were placed, although the disparity in numbers must discount the value

* 'Notre Soldat,' Lachaud, p. 94.

of such evidence. Further reference to this incident is found in the chapter on Pneumonia.

During the four years 1903-1906 the average incidence of pulmonary tuberculosis per 1,000 of strength was 2·13 in our army as contrasted with 4·57 in the army serving in France, and with 4·21 in the Army of the United States.* The Surgeon-General United States Army, in his Report for 1908, writes as follows:

'It will be seen that whereas the occurrence of tuberculosis of the lungs in our army at home is 3·35, in the British Army it is 1·9, and in both the German and Austro-Hungarian it is 1·4. It is believed that a factor in this increased occurrence must be a failure in our service to regulate the maximum number of occupants of barracks and guard-houses so as to prevent overcrowding. It is recommended, therefore, that the maximum number of men who should be allowed to occupy each dormitory or squad-room be posted on the walls or door of each room, and that this number be limited so that each man shall have a minimum air-space of 720 cubic feet; the height above 12 feet in rooms to be disregarded. In guard-houses, in cases of emergency, some degree of overcrowding may be excused, but this should, however, not be allowed beyond a minimum of 500 cubic feet, with the same disregard of height of ceilings over 12 feet.' †

During a comparatively recent passage to Bombay in a transport, of which I had medical charge, a large number of cases of tonsillitis, some of them of considerable severity, occurred amongst the men. Here again the outbreak was evidently due to some local cause, as the general health was excellent at the date of embarkation. Nor is it likely that an undetected throat could have spread the trouble, as the cases were, so to speak, dotted all over the ship, and not confined to any particular mess. The surgeon of the vessel, who kindly saw some of the cases with me, informed me that, as a result of considerable experience, he considered sore throat to be one of the commonest disabilities of life on board ship.

* Statisque Médicale de l'Armée, 1907.

† Report of Surgeon-General United States Army for 1908, p. 55.

The cases were more frequent during the latter part of the voyage.

Overcrowding in barrack-rooms, and the resulting presence of impurities of respiratory origin, are without doubt productive of sore throat, a condition which appears to be closely allied to true diphtheria. This matter will be referred to again.

Recent investigations in France in regard to overcrowding are of great interest.

The conclusions arrived at by Inspector-General Delorme, a member of the Technical Committee of the Army Medical Service at the French War Office, and formerly Director of the Val de Grâce, are as follow :

1. That disease rarely originates in barracks, be they old or new.

2. That it is generally introduced from outside.

3. That, once introduced, it spreads according to the condition or otherwise of overcrowding ; and this holds good irrespective of the age and construction of the barracks.

4. That space between barrack sleeping-cots is the most important requirement in barrack hygiene.

5. That the modern tendency is to reduce cubic space and superficial area of the sleeping-room in order to provide dining and recreation rooms, and that this tendency must be regarded as one of the great evils in connection with the barrack policy of the present day with which army medical officers will have to combat.

2. Products of Combustion.

The commonest products of combustion found in barracks are probably derived from the old-fashioned gas-burners, where the latter are still in existence. An average rate of consumption for each such burner would be about 4 cubic feet per hour. This is a liberal calculation for barracks, where the supply of gas is regulated on economical principles, and where the light emitted is often, in the words of Major Freeman, R.A.M.C., 'little better than darkness visible.'

Not less than 1,000 feet of air should be supplied in a barrack-room for each cubic foot of gas supplied.

This is a matter which is scarcely ever likely in actual practice to concern the medical officer, although it is well, in inspecting a barrack-room, to note the number of burners, and at the same time to form an opinion as to whether the fresh air supplied is sufficient. Escape of gas is far more important. According to the late Professor Corfield, small quantities produce a relaxed and ulcerated condition of the throat; large quantities cause death by asphyxia. When the gas is cut off at night and turned on again in the morning, an escape is particularly likely to occur. In the barrack-rooms where gas is turned off at 'Lights out' there is no particular danger, but in quarters where there is no restriction of the kind the possibility of serious escape is always present.

I can recall a case which nearly terminated in disaster to an officer. The gas had been cut off before the hour at which he entered his room. He went to bed by the light of a candle and omitted to turn the tap of the burner. The gas was turned on again in the small hours, and an early call, coupled with an open window, probably saved him from asphyxia.

In small quantities, coal-gas owes it deleterious properties to its sulphur compounds; in large quantities to the presence of carbon monoxide. It is stated, as regards the latter, that 'as little as 0·4 per cent. in the air may cause death from asphyxia, the gas uniting with the hæmoglobin of the red corpuscles and displacing the oxygen, so that the red corpuscles can no longer act as carriers of oxygen to the tissues, and failure of the chief nervous centres results.' *

The effect is very insidious; there is no violent struggling, such as occurs in ordinary suffocation. In fact, its mode of producing lethal results has caused its inhalation to be a favourite method of suicide amongst a certain class in many Continental cities. Giddiness, weakness in the legs, and palpitation, are among the early symptoms.

The danger of poisoning from carbon monoxide is particularly great when water-gas is supplied by municipalities. The general principle of the manufacture of this gas consists in the breaking up of steam in the presence of incandescent

* 'Hygiene and Public Health,' Parkes and Kenwood.

coke. The hydrogen of the steam remains free, while the oxygen combines with the carbon of the coke, forming carbon monoxide. What is known as Dowson gas is of the same nature. Water-gas does not consist only of carbon monoxide, but also of hydrogen, marsh-gas, etc. Carbon monoxide, however, is the only constituent which need occupy the attention of the medical officer.

The nature of the gas used in barracks should invariably be ascertained, and it would be well if a note concerning it were embodied in all sanitary reports. The use of water-gas was the subject of inquiry by a Departmental Committee in 1899, and it was recommended that the use of any poisonous gas for lighting purposes which does not possess a distinct odour should be prohibited. Recent Acts have required that the quantity of carbon monoxide in gases of this nature should be limited to 14 per cent., and that the gas should be strongly scented. The danger of the gas may be gathered from the fact that in the annual reports of the Factory Department there were at least fifty-one cases of poisoning, including seventeen deaths, between 1899 and 1903. Artificial respiration is the proper treatment in cases of poisoning; and the administration of oxygen, when possible. The advent of electric light in all barrack-rooms will, in this connection, constitute a new sanitary era.

The Welsbach light has much to recommend it, and its excellence is mainly due to the complete combustion it insures. It is well known that incandescent solid particles are the cause of the illuminating effect of the gas flame; it is also known that these particles remain solid only as long as combustion is incomplete; and that incomplete combustion is associated with the presence of carbon monoxide. By means of holes in the tube of the burner, air mixes with the gas, and excess of oxygen in the mixture determines the complete combustion of all solid matter. As the existence of the illumination depends, as just stated, on the existence of solid matter in a state of incandescence, the advantages of the result may seem rather doubtful, the flame produced, although intensely hot, having practically no illuminating

power; and it is interesting to note, according to a well-known physical law—viz., that the radiating power of gaseous bodies in a state of combustion is feeble—the absence of burning solids results in the absence of the radiation of heat which would otherwise take place, and this in spite of the high temperature reached. The light is produced by placing a mantle of incombustible material in the flame, the mantle becoming luminous under the intense heat. The principle is of great interest as illustrating the conversion of one form of energy into another; in this instance, it is the energy of heat converted into the energy of light.

It is quite evident, having regard to the above, that, on theoretical grounds, this mode of lighting should be devoid of the disadvantages connected with a high temperature and the production of unhealthy gases, and in this case the accuracy of the theory is established by actual practice. Taken as a whole, the application of the principle is thoroughly to be recommended on the score of health, economy, and absence of generally unpleasant results. Even the frequent breakage of mantles may be disregarded in view of counteracting benefits.

Gas stoves are occasionally found in barracks. If provided with thoroughly adequate flues, and ordinary precautions are taken, they are relatively free from danger. The reflector stove, which has no flue, should not be tolerated anywhere. Oil stoves and oil lamps are sometimes used in barracks, and it is commonly believed that the products of combustion in these cases do not possess any marked deleterious powers, the matter is, however, doubtful at present. Personally, I think they are objectionable; the products of combustion pollute the air of the room, and it is stated that more oxygen is consumed than in the case of coal-gas. Cast-iron stoves, from a hygienic point of view, are among the worst possible. It is well known that they give off varying quantities of carbon monoxide, and it is difficult to attribute to any other cause an ill-defined form of ill-health of which I had recent experience in barracks. The use of these stoves has been answerable for more than one tragedy. It must not be

forgotten that suffocation by carbon monoxide is devoid of the sensations attendant on the usual forms of asphyxia. The gas is odourless unless artificially scented, as it should be, and may easily cause death during sleep; or the victim, already deeply under the influence of the gas, may expire during an effort at movement, the weakened heart being unable to bear the slightest strain. This, it is believed, was the cause of the death of M. Zola, the novelist.

3. The Soil.

The air which is contained in the superficial layers of the soil is often contaminated by emanations from the decomposing organic matter which has found its way below the surface. Decaying vegetable matter, animal refuse of all sorts, effluvia from graveyards, leakage from drains and gas-pipes, and notably from cesspools, all contribute towards the same result.

Ground air is amenable to the same influences as air anywhere else, and it follows that sufficient aspirating power will draw this air in any given direction. The heated and, therefore, rarefied air of a dwelling-house or other building, or possibly of a tent or block-house, must have, to a certain extent, the above effect on the ground air beneath it, and considering the imponderable nature of bacterial forms, it is not difficult to accept the possibility that such may, in addition to gaseous matters, find their way out of the soil and into the abodes of men.

Experience in South Africa certainly conduces to a belief in such a possibility as the above, and support is obtained, in this connection, by certain well-known views of Sir Charles Cameron, who has affirmed, as regards Dublin, that the specific organism of enteric fever may be carried into the atmosphere of dwellings by movements of the ground air. It is in foreign stations, particularly, where temporary barracks are in use, that the question of ground air is likely to present itself to the attention of the medical officer. I have seen quarters in which the planking of the floor was laid directly on the surface of the ground, and I remember a quarter

in St. Helena, in which, although the planks were fixed on joists, the latter were in direct contact with the soil which there was good reason to consider as being seriously polluted with organic matter. There was no ventilation of any kind beneath the floor, nor was there anything in the way of a covering of impermeable material to prevent emanations rising from the earth. These defects were detected by a board of officers who were called upon to investigate the occurrence of a case of enteric fever in the quarters in question. It is noteworthy that there were no other cases in the garrison, and that the usual sources of infection were absolutely excluded.

In Canada and the United States, where heating by hot air instead of open fireplaces is common, it may be questioned as to how far the prevalence of diphtheria in the towns during the winter months may be caused by the aspirating effects of dwelling-houses. It is also likely that this result may be due to the multiplication of water-closets, notably in New York.

Ventilation.

If ventilation can be justly defined as the means, either natural or artificial, by which an adequate quantity of fresh air is supplied to human beings, it is plain that the location and surroundings of barracks are, as regards this matter, factors of prime importance.

Illustrations of the above fact are readily forthcoming.

Delhi is a case in point. At this station the troops are not only located within a walled city, but the British garrison occupies a fort which, although open towards the east, acts as a serious check to air coming from the other points of the compass. This is aggravated by the heat absorbed by and radiated from the sandstone walls of the fort, which are about 60 feet high.

The entrances to the fort are three in number, and two of these, known respectively as the Lahore and Delhi Gates, consist each of double archways, placed at right angles to one another, and separated by a space about 60 feet square. This space is closed in on three sides by a fortification of great

thickness, and on the fourth side by the wall proper of the fort. The scheme was no doubt excellent for purposes of defence, but at present it only serves to check currents of air, and helps to intensify the undesirable features which the fort presents as a place of residence. Figs. 21 and 22 show the arrangement of the Delhi Gate. The Lahore Gate is identical in construction with the above.

The authorities have, doubtless, had excellent reasons in the past for holding the fort by means of a British garrison. The plan, however, necessitates the maintenance of a convalescent

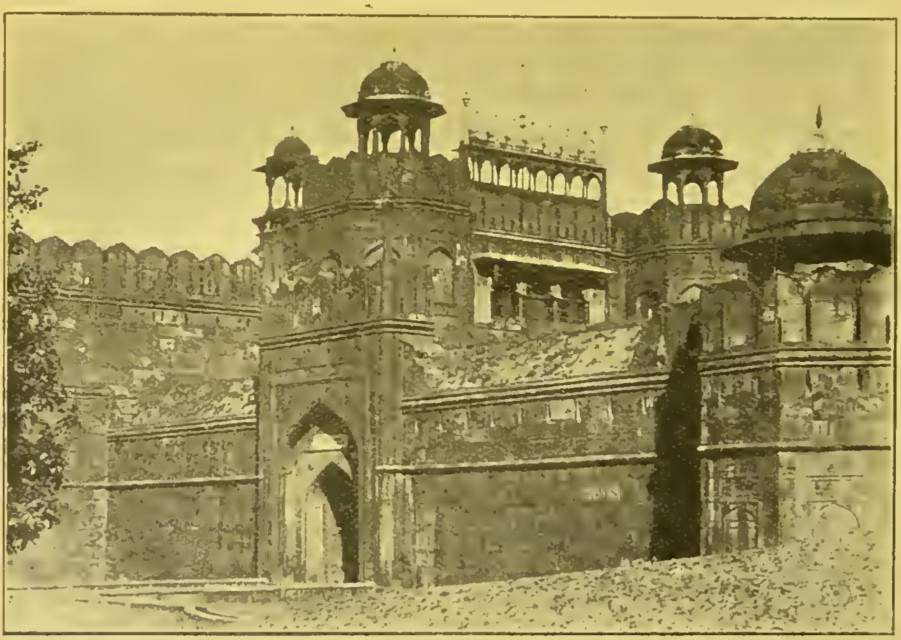


FIG. 21.—OUTER DELHI GATE OF THE FORT, DELHI.

home, the use of which is sanctioned for five months of the year. The home is established in a building of historic interest, from its association with the Mutiny, known as Hindu Rao's house. It stands on an elevated position on the 'Delhi ridge,' and is well away from other buildings. The plan of maintaining such a home is excellent, and well repays the expense which it involves.

The good effects of the home fully justify the belief commonly entertained as to the results of residence within the walls of the fort.

FIG. 22.—INNER DELHI GATE OF THE FORT, DELHI.

These results are not to be confounded with the malaria common in Delhi after the rains, but appear to be due to the absence of free circulation of air, and the great heat from the walls, during the hottest months of the year. The walls of the city naturally check currents of air, and so raise the general temperature of the area they enclose. The change in temperature is noticeable on entering or leaving the city through the Kashmir gate, this being the principal entrance.

At present there are two companies at Delhi, and Lieutenant-Colonel Berryman, R.A.M.C., kindly informs me that one is in the fort and one in the camp at the ridge ; these change places fortnightly—an arrangement which is a great improvement on the former state of affairs.

Looking at the subject of ventilation in its broadest sense, the position of barracks assumes an importance which might otherwise be overlooked. It seems far more reasonable, on sanitary and consequently on economical grounds, to locate men where natural conditions in the way of an unstinted air-supply are favourable to health, than to resort to measures which necessitate all sorts of administrative and structural complexities designed to eliminate the evil influences of surroundings which, as far as troops are concerned, might well have been non-existent.

In annual reports of medical officers the position of the barracks, relative to their surroundings, is stated at some length, but whether the actual or probable influence of the above on the health of the men is discussed in detail is quite another matter. It is only by repeated insistence that reforms can be brought about, and acts of saving effected at the expense of efficiency are very doubtful advantages from an economic point of view.

Before attempting the discussion of the internal ventilation of barracks and quarters, it should be understood that hot air expands, and in so doing loses weight inversely to its gain in volume. The rate of expansion is determined by a well-known law, which states that the volume varies directly as the temperature when the pressure is constant. Air expands at a uniform rate of $\frac{1}{491}$ part of its volume for each rise

of 1° F. The weight also, as just stated, varies inversely as the volume. Suppose, for instance, that 1 litre of air has expanded by heat into 2 litres; if we now take 1 litre of this expanded air and weigh it, it will possess exactly half the weight of the original litre. The following illustration may help to make the matter clear. A battalion in close formation is suddenly exposed to a destructive fire and opens out instantly, so that it covers exactly eight times the space that it previously did. It is evident that the numerical strength of the troops which cover the original area will be eight times less than that of the unit which previously occupied the same ground. In this illustration the area covered by the unit, or by any part of it, represents a volume of air the weight of which is, in turn, represented by the numerical strength of the men.

The hot expired air, being comparatively deficient in weight, is pressed upwards by the surrounding atmosphere, while the comparatively cold and heavy air of the latter rushes by every available channel to re-establish the balance of pressure. It follows that the light and heated air must rise until such time as it gains weight by loss of heat and consequent contraction, when it gradually sinks into the lower and denser strata. It is therefore important that the outlets should be so placed that the foul and heated air should have facilities for escape before it has time to cool. Excessive height in rooms is consequently objectionable; and outlets should be as near the ceiling as possible, as otherwise impure air may find a lodging above them, and after losing heat and gaining weight, may descend to the lower parts of the room. For this reason, windows which open directly to the ceiling are a great advantage. It should also be borne in mind that the organic products of respiration do not diffuse themselves equally through a room, but have a tendency to remain in particular parts.

It has been explained above how an inrush of atmospheric air takes place into dwellings to replace that which has expanded by heat. It is one of the objects of ventilation to introduce this entering air at a height which will not be pro-

ductive of unpleasant draughts; if this purpose can be successfully attained, the air from the exterior, being heavier than that which is in the apartment, gradually sinks by its own weight, and the sensation of chill to feet and legs is entirely avoided. Entering currents should be directed upwards.

If barracks are to be successfully ventilated, the air must be introduced in such a way as not to cause discomfort, otherwise the men will most certainly endeavour to hermetically seal every possible inlet. It has already been stated that men are not likely to suffer during the day from impure air, but there is no disguising the fact that the atmosphere of a barrack-room on a winter night tends to become most horribly foul. The fœtor is naturally aggravated when the fire dies down, and the extracting power of the flue is correspondingly lessened.

In summer ordinary cross ventilation should fulfil all reasonable requirements, but in the winter, when the men naturally prefer to keep the windows shut, other means are necessary.

It should now be evident, from what has gone before, that in considering questions of barrack ventilation the two leading factors which make for success are:

1. The establishment of outlets in those positions towards which foul and heated air naturally tends to flow.

2. The establishment of inlets at a height which will not interfere with the comfort of occupants.

It may be added that inlets and outlets should approximately correspond in areas of aperture.

Boyle's system of ventilation is based on the above principles. The inlets are placed at a suitable height, and the stream of air is directed upwards. The outlets, on the other hand, are placed in those positions indicated by Nature as being the most suitable—viz., in the highest parts of a room.

Figs. 23 and 24, for the original of which I am indebted to Messrs. R. Boyle and Son, show the application of the principle to barracks. The scheme is in existence in the

Reina Christina Barracks, Madrid, and is stated to work 'to perfection.'

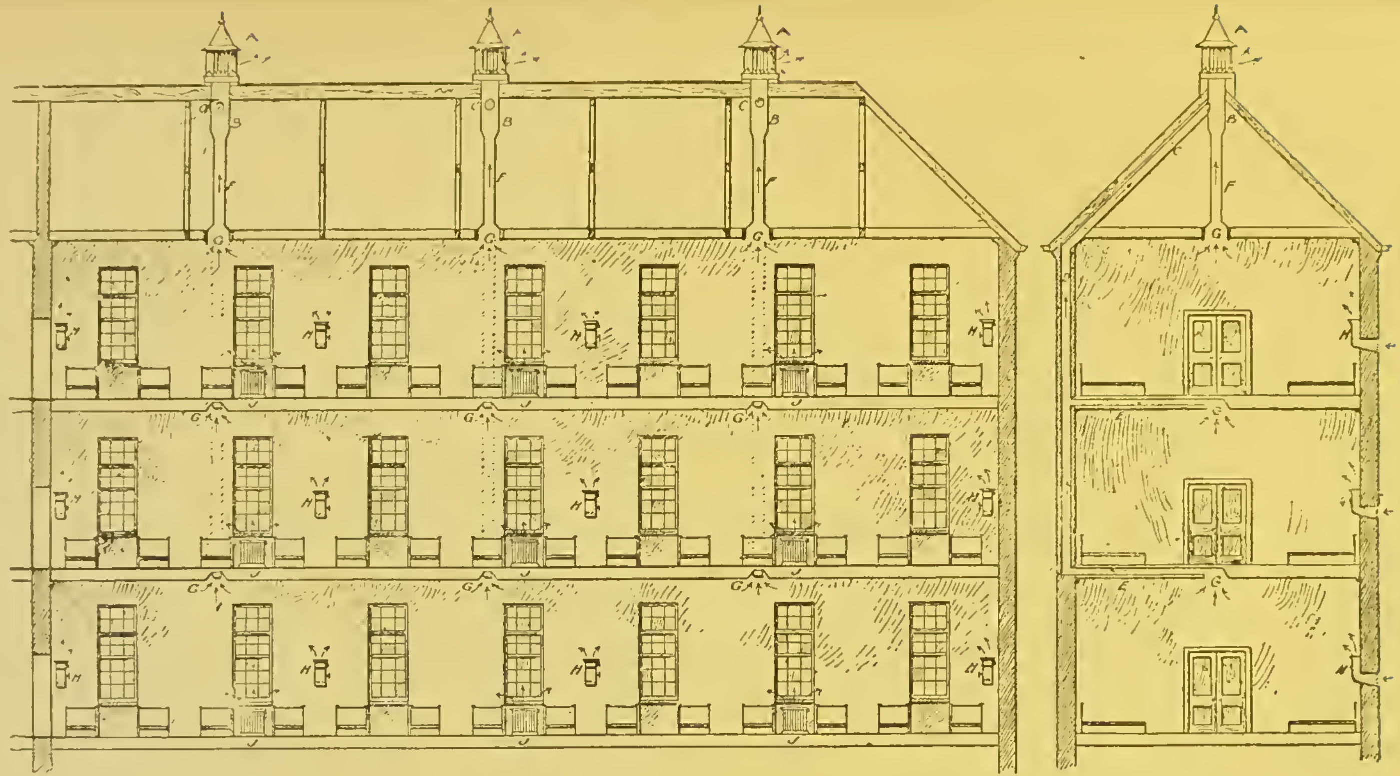
An objection to the Boyle system is, however, evident from Fig. 23; it is loss of velocity owing to the length of the tubes and the number of bends in the same. It must also be remembered that the extracting cowls depend for their effect on the aspirating power of the wind, and in a comparative calm the issuing current is almost nil. The last-named objection applies also to the revolving cowls found in the shelters of forts.

It is a noticeable feature in the above plan that the necessity for both inlets and outlets is fully recognized.

Outlets, without adequate inlets, may become useless for their original purpose. Outlets, in fact, may become inlets. To keep a fire burning in a tightly-closed room means reflux of smoke from the chimney, as the latter is the only aperture by which atmospheric air can enter to readjust the balance of pressure disturbed by the expansion of the heated air in the interior.

If the outlets can be kept warm by artificial means, so much the better. This principle is adopted in one mode of ventilation which exists in certain military hospitals. A tube, the upper end of which opens into the external air, is expanded into a trumpet shape at its lower aperture which is placed directly over a lamp used for lighting purposes; air is consequently sucked directly into the mouth of the tube.

Tobin's ventilator is one of old standing. It consists of an upright tube usually placed in the corner of an apartment, the lower end opening outside the building, and the upper end terminating about 5 feet from the floor. It is not a particularly sightly arrangement, and in barracks its utility would probably be nullified by the insertion into it of clothing or articles of another nature. It generally acts as an inlet, and is intended as such. It has been mentioned as an example of a ventilator which would probably be rendered useless if left under the control of the men. This objection does not apply to roof or ridge ventilators.



FIGS. 23 AND 24.—THE BOYLE SYSTEM OF VENTILATION AS APPLIED TO BARRACKS.

A A, Boyle's patent 'air-pump' ventilators; B B, main extraction shafts; C C, branch extraction shafts connected with upcast flues, D D, constructed in walls; E E, extraction shafts fed from upcast flues to foul air exit openings, G G, in centre of ceilings; F F, branch extraction shafts connected with foul air exit openings in centre of ceilings in top floor; H H, Boyle's air inlet brackets, for admitting screened and purified air; J J, Boyle's ventilating radiators, admitting warmed, screened, and purified air.

NOTE.—All the air inlets are fitted with regulating valves controlling the fresh-air supply, which passes direct from the outer air into the building.

A well-known and excellent ventilator of the former kind is that of McKinnell (Fig. 25). Air enters by the outer tube A, and is then deflected over the expansion B, and mixes with the rest of the air of the room; it finally makes its exit by the tube C. A cowl or cover suspended over the upper aperture of this tube will prevent the entrance of rain.

A gas jet or lamp placed close to the inner tube is a great help, but it is not essential.

In barracks the ventilators commonly consist of metal valves which are worked by cords; the latter are constantly removed or broken by the men, and the valves themselves

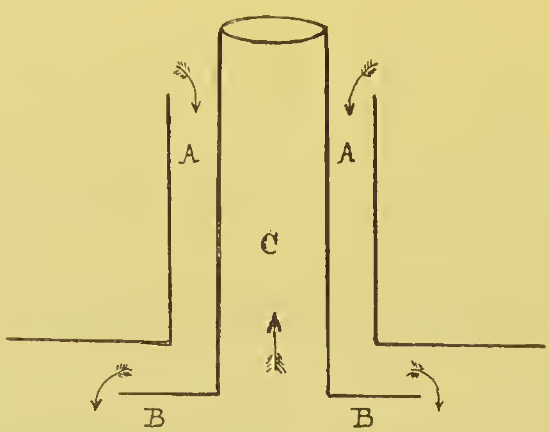


FIG. 25.—DIAGRAM OF MCKINNELL'S VENTILATOR.
Arrows show the direction of air-currents.

are frequently out of order. The method is too well known by men in the service to need detailed description.

A good means of ventilating barracks would be by the Hinckes-Bird method. This is simplicity itself, and consists in placing a block of wood under the whole length of the lower window sash. This, of course, results in the top of the sash being raised above the lower edge of the upper sash. Air can now enter the room between the sashes at a height that does not cause annoyance by the creation of draught.

There are many schemes by which warmed air might be supplied to barracks by mechanical means. Such methods are classed under the general heading of artificial ventilation.

Cubic space, under these circumstances, could be diminished, as warm air can be changed far more frequently, without causing annoyance, than air at a lower temperature. It is, however, very doubtful if such methods would be generally desirable in the case of troops.

What are known as ventilating stoves introduce a supply of air at a pleasant temperature. Unfortunately, there are many objections to stoves besides those which particularly apply to cast-iron. Stoves make the air of a room unduly dry, so much so that the defect has to be remedied by placing open vessels of water about the room.

A method often found in barracks is the introduction, by means of an opening on the exterior of the buildings, of a current of air, which passes upwards behind the fireplace and discharges inwards at a convenient height. The idea of the design is the supply of pure warm air; unfortunately, the success of the scheme depends on the heat of the fire, and even when the latter is lighted the results are apt to be disappointing.

Taking the above facts into consideration, it seems likely that Boyle's principle, in spite of obvious defects, appears to be one of the best for general use, but where this is inapplicable the Hinckes-Bird method, with the modification noted below, will probably give as good results as any other. The latter is particularly suitable to married quarters; it cannot be easily tampered with—at any rate, not without detection; does not get out of order by rust or otherwise; does not offend the eye of the soldier with the appearance of an open window; and, above all, it effects the purpose for which it is intended.

The modification referred to above is shown in Fig. 25, copied, by permission of Professor Glaister, from his well-known 'Manual of Hygiene.' The modification is Professor Glaister's design, and is thus described by him: 'There is only one block, which is always at hand, and serves for all weathers. This is effected by counter-sinking into the lower frame of the lower sash a movable teak block, which may be lengthened or shortened by means of two screws working

in brass slots. When this block is pushed home it is flush with the level of the frame.'* A distinct drawback in the original form is the necessity for blocks of different size to regulate the height of the lower sash. Professor Glaister's design entirely obviates this defect. It might, with great advantage, be introduced into married quarters.

Sheringham's valve consists of a plate in the wall near the ceiling. It is provided with side-checks and a counterpoise,

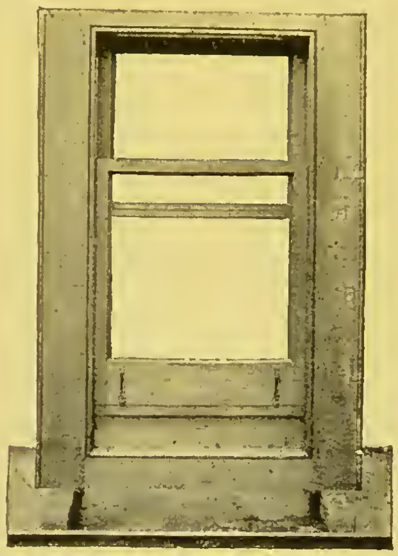


FIG. 26.—A METHOD OF WINDOW VENTILATION SUGGESTED BY PROFESSOR GLAISTER.

It may be made to act as an ordinary sash window with up-and-down movement. It is a modification of the Hinckes-Bird arrangement. There is only one block, which is always at hand, and serves for all weathers. This is effected by countersinking into the lower frame of the lower sash a movable teak block, which may be lengthened or shortened by means of two screws working in brass slots; when this block is pushed home it is flush with the level of the frame ('Manual of Hygiene for Students and Nurses,' by John Glaister, M.D., D.P.H.).

so that it can be closed or opened as desired. The air is commonly admitted through a perforated iron screen. The angle which the upper surface of the plate forms with the external opening is always less than a right angle, so that the entering air is directed towards the ceiling. This ventilator would answer well for offices, quarters, etc., but in barrack-rooms it would be very liable to damage by rough usage. I

* 'Manual of Hygiene for Students and Nurses,' by John Glaister, M.D., D.P.H., p. 52.

have known it answer well in the sergeants' mess and the canteen.

Ellison's perforated bricks are a fairly common means of ventilation. The openings are trumpet-shaped, the larger end being inside the house, so that the air is diffused on entry. If they proved to be an annoyance, they would very soon be plugged up by the men.

A suggestion which would be well worth the careful consideration of the War Office is that of Dr. Parkes and Kenwood—viz.: 'To construct a shaft at one side of or surrounding the chimney flue, with an inlet near the ceiling of the room and the outlet at the level of the chimney-top. The air escaping from the room will then have its temperature kept up by contact with the chimney flue, thus aiding the up-draught, while the risk of reflux of smoke will be avoided.'*

Ventilation on board ship is a subject which can scarcely fail to occupy the attention of medical officers in charge of transports. There seems to be a prevalent idea that the revolving electric fans which are often in use do all that is required in furnishing a sufficient supply of fresh air; in reality, the only result which their presence effects is the constant movement, but by no means the removal, of the foul air which collects in cabins and between decks. No doubt they have a cooling effect, and are so far conducive to comfort, but they cannot be rightly regarded as an adequate means of ventilation in the proper sense of the word. Exhaust fans, if large enough and placed in suitable positions, are excellent as a means of removing foul air, but this foul air is sometimes replaced by more of the same nature from the other parts of the ship. The use of exhaust fans together with wind-sails answers well, but a great deal must depend on where the exhaust fans are placed. When hatches are battened down, an exhaust fan would have for its main effect the transference of air from one part of the ship to another. To insure the purpose for which the fans are intended, a liberal supply of fresh air should be available, either by means of propulsion or by wind-sails.

* 'Hygiene and Public Health,' Parkes and Kenwood.

By this combination of exhaustion and supply, a current of air can be passed more or less from stem to stern of a ship.

Ships are, of course, not all constructed alike, and apart from fundamental differences of design, the problem of ventilation presents varying aspects according to the weather, the winds, the number of persons on board, the nature of the cargo, etc. It is stated that good ventilation can be obtained on board steamships by utilizing the heat of the furnaces to extract the air from other parts of the ship, through special shafts.

The electric blowers with which transports are now fitted are some aid to ventilation ; a leading defect is insufficient number. By means of tubes furnished with electric fans a constant supply of air is propelled from above to the mess decks, and ventilation is thus made independent of the ports —a fortunate circumstance where the ship is rolling heavily ; the system is, nevertheless, incomplete, as it is not only necessary to introduce fresh air, but to remove that which is foul, and for the latter purpose something in the nature of exhaust fans is required.

The right time to get a really sound idea of the ventilation below is to visit the mess decks between 'lights out' and reveille. On the Cape voyage, when the ship is running in the North-Easterly Trades, this inspection is highly instructive, as the following wind prevents the current of air which is necessary for health and comfort ; of course, when the ship strikes the contrary winds south of the line, the conditions are immediately changed for the better.

On some transports it is the rule that no men are to be allowed to sleep on deck the night before entering port. This may be necessary at times, but often there is no justification for it whatever, except 'custom,' and it is a point to which the medical officer would do well to pay particular attention.

Experience gained on transport duty cannot be compared with that of medical officers of the Royal Navy or of the passenger service, and the above remarks are by no means

intended as dogmatic assertions with regard to questions concerning which others are far better qualified to form accurate opinions.

There are, in conclusion, a few simple facts concerning problems of ventilation which, in view of their general applicability, are worth committing to memory.

1. That the loss in velocity of air, by friction, in a shaft is directly as the length of the shaft. In other words, with a shaft 1 foot long and another shaft 2 feet long, the loss in the second would be double that in the first. The sectional area is, of course, presumed to be the same in the two shafts.

2. For shafts of unequal size the loss by friction varies inversely as the diameter of the cross section in each. This is an important rule to remember, as it makes clear the fact that an undivided opening of 1 square foot is by no means the same thing as an opening of 1 square foot divided into four equal parts. The diameter of each of the four small squares is half that of the large undivided square, and the loss by friction will be consequently doubled in the case of the divided opening.

3. A circle is a figure which contains the largest area within the smallest periphery, and as the smaller the periphery, with equal areas, the less the friction, it is evident that all ventilating shafts should be circular. In the case of two shafts, each of 1 square foot area, one shaft being a circle and the other a square, the velocity of the current through the square shaft will be $\frac{3\frac{1}{2}}{4}$ that of the velocity through the circular shaft, the periphery of the shafts being respectively $3\frac{1}{2}$ feet and 4 feet.

4. Each right-angled bend in a shaft diminishes the velocity of the air-current by one-half.

By keeping these rules in mind, medical officers and others can come to just conclusions concerning many questions connected with ventilation, which they are liable to encounter in the daily discharge of duty. It is particularly when acting on boards concerning the fitness of quarters for

occupation, that a knowledge of these rules is likely to be useful. A few years age I saw a quarter, which must have been passed as fit for occupation at some time, with a ventilating shaft, from the drain, diminished by half its diameter in the last few feet of its course, and having no less than two right-angled bends. I have reason to believe that the house was built by a contractor who had evidently designed the sanitary arrangements more with regard to his own interests and convenience than with reference to the requirements of the health of future occupants. Perhaps he considered that the pan-closet he had provided would, at certain times, act as a suitable means of sewer ventilation. The above is an illustration of the probable advantages which will accrue from the appointment of sanitary specialists. To detail officers for sanitary duties, without any regard to particular qualifications, can scarcely be considered a sound procedure. It is one thing to place any available medical officer on a board directed to inspect completed quarters, and another thing to submit the plans of such quarters, before construction, to a specially appointed officer skilled in sanitary science; it is to be hoped that the latter course may become invariable, although at present it is far from being so.

When medical officers were, to use a well-known epithet, 'scarcely better than camp followers,' any such interference would not have been tolerated, but in more enlightened times it is accepted as a thoroughly sound principle that the public service should avail itself, to the full, of knowledge which, apart altogether from a purely humanitarian point of view, has, without question, a distinct economic value.

CHAPTER XVI

FOOD

THE animal organism has been aptly compared to a steam-engine, of which the fuel is the food we consume, of which the draught is the air we breathe, and of which the actual structure is comprised in the various tissues of the body. Just as the heat generated in a railway locomotive furnishes the energy necessary for the movement of the train, so the heat generated in our bodies furnishes the energy necessary for the various movements of which the sum total constitutes what we call life. Burning consists essentially in the union of the oxygen of air with other bodies ; it may therefore be spoken of as oxidation. When the union is rapid and takes place on a large scale, great heat is evolved ; and when it takes place on a lesser scale, the heat is correspondingly diminished; so that we can get every degree of heat, from that produced by the blast of a Sheffield furnace to the comfortable and quiet process that goes on within our own persons.

It is well known that for a machine to discharge its functions satisfactorily four things are necessary :

1. The fuel must be suitable as regards quantity and quality.
2. The draught must be sufficient.
3. The ashes must be removed.
4. The machine itself must be repaired from time to time.

The fuel of the animal machine consists of three classes of food :

(*a*) *Carbohydrates*—viz., combinations of carbon, hydrogen, and oxygen, the hydrogen and the oxygen being in the proportions necessary to form water, which means that there is twice as much hydrogen present as there is oxygen.

This group is broadly represented by sugars and starches, the former consisting of cane-sugar, represented by the formula $C_{12}H_{22}O_{11}$, and glucose or grape-sugar, represented by the formula $C_6H_{12}O_6$. The starches are represented by $C_6H_{10}O_5$, and are converted into glucose by combination with water, thus: $C_6H_{10}O_5 + H_2O = C_6H_{12}O_6$, a change which can be effected by certain ferments—such, for instance, as ptyalin in the saliva, and ferments in the pancreatic juice.

There are other sugars besides those named, but these do not concern us at present; one of them—viz., maltose—will be considered in the chapter on Alcohol.

(*b*) *Fats*.—These are combinations of carbon, hydrogen, and oxygen, but contain much less oxygen than the carbohydrate group.

The large majority of fats are comprised in the compounds stearin, olein, and palmitin, each of which consists of the radicle glyceryl, represented by C_3H_5, combined with either the stearic, oleic, or palmitic acid radicle. Stearin is represented by $C_3H_5(C_{18}H_{35}O_2)_3$, olein by $C_3H_5(C_{18}H_{33}O_2)_3$, and palmitin by $C_3H_5(C_{16}H_{31}O_2)_3$.

Olein is the main constituent of olive oil and almond oil, stearin of suet from either beef or mutton, palmitin of palm oil, while human fat consists of all three of the above-named compounds.

(*c*) *The Nitrogenous Group*.—This consists of animal and vegetable compounds containing nitrogen, and commonly called proteins. This group not only serves as fuel, but likewise makes good the actual wear and tear of the animal frame—that is to say, it is a repairing group as well as a fuel group. In addition to nitrogen, all proteins are composed of carbon, hydrogen, oxygen, and sulphur, with sometimes phosphorus.

Water is, of course, necessary for life, and also certain salts which are largely found in fruit and vegetables; it was the absence of these salts which, in the old days, played havoc among sailors and soldiers, by the production of scurvy.

We may now consider the four factors necessary for the successful working of the machine:

1. Suppose that the quantity of fuel is excessive: a portion of the excess is probably not burned at all, and this may be represented by the accumulation which undergoes unwholesome fermentation in the overloaded stomach of the glutton; another portion is only partially burned, and as partial oxidation of food results in the production of fat, is represented by the fat which accumulates on the persons of those who habitually consume food in excess of actual requirements. If the quantity is satisfactory, the quality may not be so; for instance, if we have an excess of carbohydrate with insufficient protein, the body is likely to suffer. Bread mainly consists of the common carbohydrate starch, with a small quantity of protein in the form of the gluten of the wheat, and if man was forced to live on bread only, he would consume an excess of carbohydrate in order to obtain the necessary amount of protein; if, on the contrary, only lean meat, which belongs to the nitrogenous group, was available, he would run the risk of poisoning himself in order to obtain the fuel necessary for life.

2. If the draught is inadequate, the results named above in connection with excessive fuel naturally ensue, it being evident that for complete oxidation there must be a satisfactory relationship between the quantity of food eaten and the quantity of oxygen inhaled. It follows that persons leading sedentary lives require less food than those who lead active lives in the open air.

Excess of diet and insufficient exercise result in failure of complete oxidation, with production of fat and relatively large quantities of bodies, of which uric acid ($C_5H_4N_4O_3$) may be considered as a representative.

3. The results of satisfactory oxidation comprise uric acid (named above), urea (CH_4N_2O), and other bodies which need not now be considered. It must be understood that uric acid is normally present in the body, and it is only in excess that its presence must be considered as unfavourable to health.

The results which represent the ashes of the fire consist of solids, liquids, and gases: the two former are removed

by the intestines and kidneys, and it is a matter of common knowledge that free elimination is essential for health and comfort; the latter leaves the body by the lungs, principally in the form of carbonic acid.

4. The actual repair of the machine is effected by the nitrogenous group of foodstuffs, the latter being represented in our dietaries by eggs, lean meat, fish, cheese, and poultry. It must not, however, be inferred that the above consist exclusively of protein, but only that the latter preponderates.

It will be seen later that there is some reason to believe that the machine wears out comparatively slowly, and the question is thus raised as to whether most of us do not consume more meat than we require.

The effect of excess of fuel has now been considered, but not its deficiency. If food is withheld, the machine, for some time, uses its own structure as fuel. First the fat is consumed, next the muscles and other of the soft tissues, lastly the bones are attacked; and when all the available fuel has been used up the fire flickers and goes out, or, in plain English, the unfortunate individual dies of starvation.

If what has gone before is accurate, we can now understand that the object of every dietary should be to adapt the amount of fuel to the exigencies of the task, being careful that the fuel is not accompanied by an excess of repairing material—in other words, that the proportion of carbohydrate to protein food is carefully maintained.

Physiology affirms that a healthy man during an ordinary day's work requires, in round numbers, 300 grains of nitrogen and 5,000 grains of carbon, and the daily ration of the British soldier has been estimated to contain approximately these quantities of each of the elementary substances in question. The home ration is partly made up of a 'free' issue of $\frac{3}{4}$ pound of meat and 1 pound of bread, while for such articles as tea, sugar, vegetables, etc., the soldier pays a messing charge of 3d. or 4d. a day. The following dietaries, taken from two companies of the same regiment, are fairly typical of what the soldier actually receives when the messing is in good hands, as, in fact, it almost invariably is:

BAND AND BUGLERS, 1st KING'S OWN YORKSHIRE LIGHT INFANTRY.

SCALE OF DIET FOR WEEK ENDING JANUARY 15, 1910.

Meals.	Sunday.	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.	Remarks.
Breakfast	Tea, bread, pork chops and mint sauce	Tea, bread, butter, and Quaker oats	Tea, bread, and meat	Tea, bread, and fish	Tea, bread, and meat	Tea, bread, liver and bacon	Tea, bread, and meat	
Dinner ...	Roast mutton, potatoes, and apple pie	Brown stew, potatoes, and suet dumplings	Roast meat, potatoes, and Yorkshire pudding	Preserved meat, potatoes, and sago pudding	Roast meat, potatoes, and stewed gooseberries and custard	Plain stew, potatoes, and rice pudding	Meat and potato-pie, and peas	
Tea ...	Tea, bread and butter	Tea, bread and jam	Tea, bread and dripping	Tea, bread and butter	Tea, bread and dripping	Tea, bread and butter	Tea, bread and butter	

WYNBERG, CAPE COLONY,
January 6, 1910.

R. E. BOULTON,
Captain commanding Band and Buglers.

E COMPANY, 1ST KING'S OWN YORKSHIRE LIGHT INFANTRY.

SCALE OF DIET FOR WEEK ENDING MARCH 5, 1910.

Days.	Breakfast.	Dinner.	Tea.
Sunday	Tea, bread, and stewed meat	Roast meat, potatoes and vegetables, macaroni pudding	Tea, bread and butter
Monday	Tea, bread, herrings, and tomatoes	Brown stew, potatoes and vegetables, peas	Tea, bread and dripping
Tuesday	Tea, bread, and stewed meat	Roast meat, potatoes and vegetables, Yorkshire pudding	Tea, bread and butter
Wednesday	Tea, bread, liver and bacon	Preserved meat, potatoes, haricot beans, rice pudding	Tea, bread and butter
Thursday	Tea, bread, and stewed meat	Roast meat, potatoes and vegetables, tapioca pudding	Tea, bread and butter
Friday	Tea, bread, and fried fish	Tomato stew, potatoes and vegetables, currant rolls	Tea, bread and butter
Saturday	Tea, bread, and cold meat	Roast meat, potatoes and vegetables, peas	Tea, bread and butter

WYNBERG, CAPE COLONY,
February 25, 1910.

Approved: L. H.,
Lieutenant-Colonel commanding
1*st K.O.Y.L.I.*

H. S. KAYE,
Lieutenant commanding E Coy.,
1*st K.O.Y.L.I.*

The field ration is on a more liberal scale than that authorized in peace. It contains everything essential, but, of course, it has to be modified according to circumstances.

An enormous number of calculations have been made to show a scientific connection between the food consumed and the amount of work to be done. Unfortunately, the value of the results is discounted by the fact that the digestive and assimilative powers vary, not only among individuals, but also according to general health, climate, season of the year, habits, etc. In short, men can only in a limited degree be compared to steam-engines, the output of which in work has an exact mathematical connection with the amount of fuel which is used. No doubt there is an exact mathematical connection in the case of men also, but the conditions which govern it are so various and so imperfectly understood that, at present, it cannot be fairly said to exist for any practical purpose. Although such figures, as those just referred to, are doubtless of great scientific value, they should not therefore be regarded as other than approximate, and in the meantime the practical fact remains that, as a broad general rule which has few exceptions, the physical condition of the recruit is one of steady improvement. It consequently appears needless to dwell at any length on points of pure theory, and we may accept the fact that the diet allotted to the soldier is ample, and that, assuming the excellence of the quality of the food, there is no necessity to consider the question of sufficiency.

It will suffice, then, to say that the uel value of food is measured in 'calories,' 'calorie' being the amount of heat necessary to raise the temperature of 1 kilogramme (2·2 pounds) of water through 1° C. (1·8° F.). One gramme of protein or carbohydrate is supposed to be equal to 4·1 calories, and 1 gramme of fat to 9·3 calories. The following table shows standards adopted by different nationalities, and for different kinds of work :

	Protein.	Fat.	Carbo-hydrate.	Calories.
	Grammes.	Grammes.	Grammes.	Grammes.
Atwater: No work	100	—	—	2,700
Atwater: Light work	110	—	—	3,000
Atwater: Moderate work	125	—	—	3,500
Atwater: Hard work	150	—	—	4,500
Atwater: Very hard work	175	—	—	5,500
Average food supplied gratis to four British regiments ...	133	115	424	3,369
Food supplied free to seamen, Royal Navy	91	48	406	2,585
French Army peace ration ...	125	60	573	3,426
German Army peace ration ...	144	56	500	3,161
United States Army peace ration	157	140	603	4,179
Russian Army peace ration ...	155	57	648	4,080

Report of the Committee on the Physiological Effects of Food, Training, and Clothing on the Soldier (*Journal of the R.A.M.C.*, June, 1909).

As a matter of fact, it has been recently pointed out that it is possible that the soldier's allowance of food, as regards meat, is not only sufficient, but actually excessive. Without dwelling on matters of detail, evidence has been brought forward by an American physiologist, Professor R. Chittenden, tending to show that the average man habitually consumes more than twice as much protein food as he actually needs. In this connection we know that after hard exercise the amount of nitrogen leaving the body is only increased within narrow limits—in fact, some observers assert that it is not increased at all; we also know that the muscles are largely nitrogenous in constitution. It might be inferred that if the muscles were worn away by exertion, there would naturally be a largely increased output of nitrogen, but as we have seen, this does not take place; but what does take place is a material increase in the amount of carbonic acid leaving the lungs. We know that the energy of movement is produced by the burning of the food we have eaten; we know that carbonic acid is an invariable product of the act of burning; we know that the muscles do not rapidly waste as a result of exercise, so we may come to the conclusion, on theoretical grounds, that, provided the supply of fuel material is maintained, the supply of mending material is comparatively of

slight consequence. We all know that the most ingenious theories often break down hopelessly in practice, but in this case Chittenden's experiments appear difficult to refute.* (See p. 312.)

The whole question needs further elucidation, and for the present we would do well to keep judgment in suspense. It is quite certain that if the British soldier gets more meat than he needs, he thrives remarkably well on the excess.

Those who are interested in the subject would do well to read a most able and thoughtful article by Major R. J. Blackham in the *British Medical Journal* of August 8, 1908, and originally produced in the form of a paper at the Annual Meeting of the British Medical Association, in the same year.†

The question of quality, as far as bread and meat are to be considered, concerns, in the first place, the supply department, but the fitness for daily issue, in large stations, is determined by a mixed board of which a medical officer is a member. In small stations the opinion of the medical officer is not taken as a matter of course, but it is always available as a final decision if doubt arises.

It would be an act of needless repetition to detail the recommendations which have been frequently set forth, with great ability, concerning meat inspection. No written descriptions can, however, convey the information which is to be gained by an hour spent in actually examining carcasses, and hearing an accompanying explanation from an intelligent non-commissioned officer whose duties lie in this particular province. There are nevertheless one or two points which are well worth dwelling on. One is the examination of the pleura or membrane which is found lining the inner side of the ribs and whole interior surface of the chest. This membrane should be smooth to the finger, and of a somewhat glistening appearance. Roughness is a sign of disease, and if not sufficient in itself to justify the rejection of the carcass, it should certainly call for the inspection of the internal organs, and particularly

* 'Nutrition of Man,' 1907; 'Physiological Economy in Nutrition,' 1905.

† 'The Feeding of the Soldier in Barracks, in Hospital, and in War,' by Major R. J. Blackham, R.A.M.C., D.P.H.

the lungs. If the pleura has been stripped from the ribs, there is good reason to suspect that an effort is being made to conceal the existence of disease, and great caution should be exercised in passing such carcasses. The lymphatic glands should also be carefully examined, as they may afford excellent indications of the presence of tuberculosis. Enlarged lymphatic glands are most suggestive of this condition. There is a chain of lymphatics near the spine, but they are commonly removed by the butcher before inspection. As one of the principal reasons for meat inspection is to guard against tubercle, it may not be out of place to refer to the report of the Royal Commission (1895) appointed to inquire into the effect on health of the consumption of tuberculous meat. The following principles are laid down :

(*a*) When there is miliary tuberculosis of both lungs ; (*b*) When tuberculous lesions are present on the pleura and peritoneum ; (*c*) When tuberculous lesions are present in the muscular system or in the lymphatic glands embedded in or between the muscles ; (*d*) When tuberculous lesions exist in any part of an emaciated carcass,	The entire carcass and all the organs may be seized.
(*a*) When the lesions are confined to the lungs and the thoracic lymphatic glands ; (*b*) When the lesions are confined to the liver ; (*c*) When the lesions are confined to the pharyngeal lymphatic glands ; (*d*) When the lesions are confined to any combination of the foregoing, but are collectively small in extent,	The carcass, if otherwise healthy, shall not be condemned ; but every part of it containing tuberculous lesions shall be seized.

It is evident that, to apply these principles in their entirety, the internal organs ought not to be removed before the carcass is inspected, and it follows that meat inspection as carried out in the service leaves something to be desired. It is not safe to accept lungs, or other parts, already removed, as evidence of the healthiness of an animal, as it would be quite easy to substitute healthy for diseased viscera.

To arrive at a really sound opinion as to the suitability of meat for ration purposes, carcasses should be examined with the lungs and abdominal viscera in position. In small stations this might not be possible, and in these cases a trustworthy representative of the military authorities should be present when animals, the meat of which is intended for rations, are slaughtered. The practicability of this measure is proved by the fact that it was carried out at St. Helena without difficulty, and with good results. Regarding the effect of cooking upon the tubercle bacillus, the observations of Dr. Woodhead are well worth quoting:

'In the boiling and roasting experiments, as ordinarily carried out in the kitchen, the temperature, however high it may be near the surface, seldom reaches 140° F. in the centre of a joint, except in the case of joints under 6 pounds in weight. Ordinary cooking is quite sufficient to destroy any smeared (infective) material that remains on the outer surface of the meat, but it cannot be relied upon in the slightest degree to render innocuous the same smeared material when in the centre of a roll.'

In view of these conclusions, the importance of careful meat inspection is sufficiently obvious. Putrid meat is, of course, to be detected without difficulty by the odour, but occasionally, in hot weather, contractors are apt to affirm that the surface of the meat may be tainted, although the interior is perfectly sound, at the same time pointing out that meat in the summer months cannot be prevented from superficial decomposition. The matter is readily set at rest by plunging a knife into the interior of the joint and ascertaining, after withdrawal, if the point has a smell of putrefaction, or else by cutting straight into the flesh and opening it out.

I well remember a contractor making every effort to induce a belief on my part that the fœtid carcass which he had brought into barracks was only affected on the surface, and was actually prime meat. Examination of the interior of the muscles left no doubt as to the inexactitude of his statement. The meat was removed from the store and was a few hours afterwards identified by me at the request of the police, who had taken the would-be vendor into custody for exposing unsound food for sale. Another case also occurs to my memory, in which, after the contractors' meat had been passed by a Garrison Board, several excellent joints were removed and replaced by decomposing fragments of the most repulsive description. This incident occurred at a foreign station, and it is to the credit of British tradesmen that complaints, although not unknown, are rarely heard of. Enough has probably been said in this connection to indicate certain advantages which would accrue from the introduction of military stock farms. In St. Helena, although there was no institution of the kind, the War Office, in 1898, arranged for a supply of English cattle for the troops. This measure met with strong opposition on the part of the Government contractors, who endeavoured to prove that the cattle were diseased at the time of landing, and that their own stock would consequently be endangered. A thoroughly careful and impartial investigation, at which the contractors were invited to be present, left no doubt as to the good condition of the beasts, and, except as far as private interests were concerned, the measure in question gave universal satisfaction. In India, stock, apart from that which is raised on the Government farms, is purchased alive by the supply department and killed in Government slaughter-houses. The system is an excellent one, and with ordinary care it should practically insure safety in the direction of ration meat. It is much to be desired that a similar arrangement could be made universal at home.

By the use of sodium sulphite a dishonest tradesman can impart an actually inviting colour to all sorts of unwholesome offal. On the Continent large quantities of meat absolutely

unfit for consumption are sold by this means. In America meat treated as above is known as 'Hamburg steak,' and in Germany as 'Hackfleisch.' The fraud should easily be detected, as the bright colour is only found on the surface of the meat.

Daily samples of milk, both for the sick and for use in barracks, should be submitted to examination by a medical officer. The usual method of examination, which, by the way, might well be made the matter of routine in certain regimental institutions, consists in ascertaining the reaction to litmus-paper, which may be faintly acid, alkaline, or possibly neutral; taking the specific gravity; and, lastly, roughly estimating, by volume, the proportion of cream. The specific gravity should vary from 1030 to 1032, and the volume of cream should not fall below 6 per cent.; this information is obtained by the use of the lactometer, and by allowing the milk to stand in a cylindrical glass vessel until the cream has risen. As this elementary scheme of examination requires no particular skill, it would have an excellent field of utility beyond the walls of the military hospital.

It is necessary to form an estimate of the cream, as, although its removal would raise the specific gravity of the milk, the addition of water would readjust the balance, and an act of fraud would thus escape detection. This fact was impressed on my memory in a practical manner when assuming charge of a hospital in barracks situated in a commercial centre. I was assured that the milk was of excellent quality, and as far as taste, specific gravity, and appearance on delivery were reliable indications of excellence, this was no doubt the case. Further examination revealed, however, the almost entire absence of cream, the addition of water, and wholesale adulteration of an uncertain nature. What the adulterant actually consisted of I was never able to ascertain, but sophistication had certainly been practised with no small degree of skill. I shortly afterwards inspected the so-called dairy from which the milk was obtained. It was situated in a crowded thoroughfare, and comprised a small shop, of singularly uninviting appear-

ance, which answered the double purpose of a milk-store and the emporium of a general dealer. At the back of the shop was a dark and foul-smelling shed, where the cows passed a precarious existence, and where milking operations were conducted by an individual who, to judge from his appearance, was chronically in need of washing, and under general conditions which, apart from the above, insured contamination of the supply with all sorts of unnamable filth. I am happy to say that early representations were the means of obtaining milk elsewhere. The incident may be

FIG. 27.—MILCH COWS FOR THE USE OF EUROPEAN TROOPS, DELHI.

worth recording, as it illustrates the necessity of not only examining the milk, but of inspecting its actual source. Perhaps in the future the War Office will be the owner of dairy farms, under military control, throughout the country. It would be impossible to formulate, at present, detailed proposals, although the desirability, as a general principle, of the measure in question may be fully admitted. As it is, this means of supply is not unknown. At Aldershot cows are kept with, I believe, the best results, on the sewage farm,

and in some other stations the same arrangement exists in a modified form. India is far ahead in this and in other branches of supply, the general principle of official control being accepted, although details of administration differ according to local circumstances. At Delhi the cows are kept in the fort, and milked under supervision; there is also an excellent dairy in the fort, and it is clear that, apart from all other manifest advantages, the difficulty

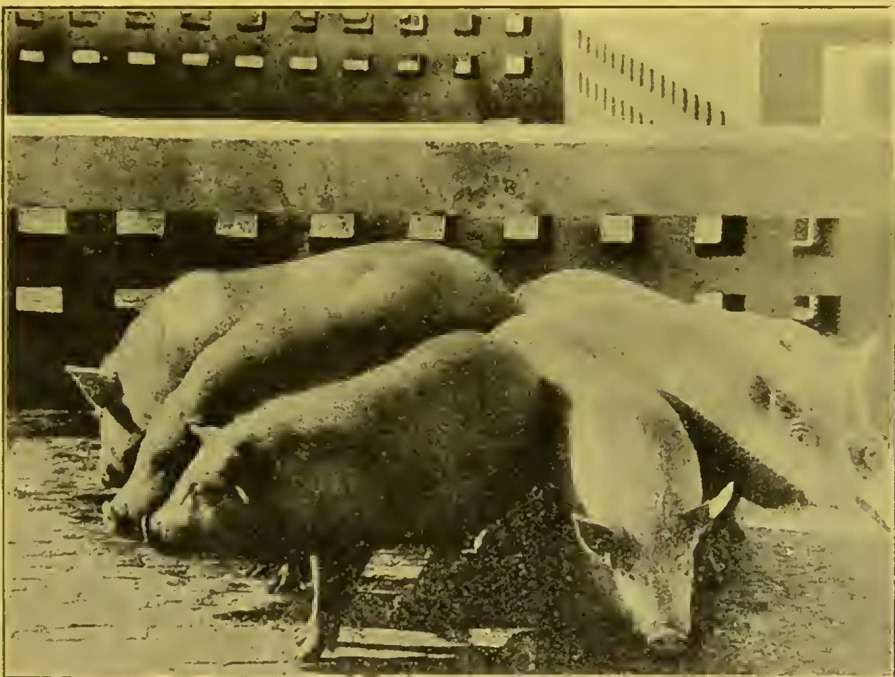


FIG. 28.—PIGS BRED ON GOVERNMENT FARM.
Copied, by permission, from the 'Farm Manual.'

which these arrangements present in the direction of fraudulent enterprise is a gain which is too evident to be disputed. The system of military dairies obtains throughout India, and there is no doubt that these institutions, being as a whole admirably managed, are of the greatest benefit to the State by the protection they afford against the most deadly forms of epidemic disease. At Allahabad, in particular, there is a dairy which supplies a very large number of stations with the best of produce. This is one of the largest dairies in India.

It was at Allahabad that the first Government farm was established by the late Lieutenant-General Sir Hubert Macpherson. 'His unflagging zeal set the scheme going, and the practical lines he laid down for its working have directly led to a success that is to-day justifying the existence of similar farms all over the country.'* There can be no doubt as to the widely-spread benefits of the farms. Full details of their working can be found in the 'Farm

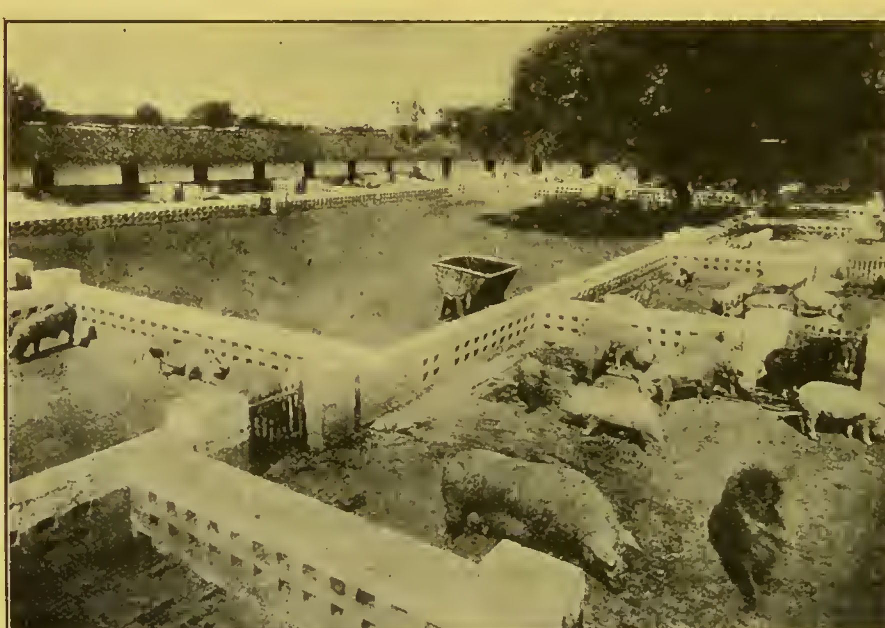


FIG. 29.—MODEL PIGGERY.
Copied, by permission, from the 'Farm Manual.'

Manual,' published by the Superintendent of Government Printing, Calcutta. The book should be full of interest to military sanitarians, as it affords an excellent example of going to the very root of the food question for troops—viz., the supply of an army by itself. It is the work of Major A. C. Williams, Chief Supply and Transport Officer, Meerut, and Major D. J. Meagher, late Superintendent of Grass Farms, and, as stated by the authors, was begun at the instance of General Sir George White. Fig. 28 shows specimens of

* 'Farm Manual,' Preface.

the animals raised, and Fig. 29 may serve as a general indication of the way in which the work is done.

It is well known that enteric fever, scarlet fever, diphtheria, and tubercle, all spread through the medium of milk. In our present state of knowledge, boiling the milk may, in the absence of a special sterilizer, be considered the best safeguard in the way of general applicability against each of the above. It is not, however, always possible to insure the process being carried out, and boiling, it must be remembered, will not affect poisons which have been generated in the milk, although the bacteria themselves may have been killed. If the milk is to be boiled, it should be boiled at once; in other words, as soon as possible after milking, and not after hours of exposure to sun, dust, and dirt of all kinds, with the additional results of long jolting in a train or milk-cart. These facts, coupled with the connection just named between milk and certain diseases, are strong arguments in favour of the War Office taking the supply of dairy foods into its own hands, and the same principle may be extended to other branches of supply.

Bread may be defined as dough in which carbonic acid has been generated or into which it has been forced, and the mass subsequently baked; it is usually made by mixing yeast with wheaten flour, water, and salt, and allowing the yeast to ferment. By the action of the fermenting yeast the starch is partly changed into sugar, and the latter into alcohol which escapes into the air. Carbonic acid, which is also evolved, cannot escape, being, so to speak, entangled by the dough, and, forming little chambers for itself by its expansion, it gives to bread the characteristic spongy appearance which is so familiar.* Certain points in this method of bread-making require particular attention. It is essential that the yeast should be of good quality, and that the fermentation should not be allowed to proceed unrestrictedly, as, in the event of the process not being checked at the right time, acids (lactic, butyric, acetic) are formed, the presence of which results in

* For further details see 'Training for Army Service Corps,' Part II.

the production of a sour and unwholesome loaf. Alum is used to check over-fermentation; it also whitens the bread; it tends to produce constipation and dyspepsia, and is therefore undesirable. The presence of salt is not a necessity; in France it is largely omitted. Bread can also be made by means of powders which evolve carbonic acid in the substance of the dough. These powders, which consist of the bicarbonate of an alkali, together with an acid such as citric or tartaric, are extensively sold under the name of 'baking-powders.' They are occasionally found to contain alum, and should not then be used. Baking-powders are a great advantage on service. In the late winter and early spring of 1902 I had charge of the blockhouses between Harrismith and Oliver's Pass in the Drakensberg, and subsequently of those in the neighbourhood of Tyger Kloof. The men suffered considerably from dyspepsia; this was caused, I think, by the prolonged use of biscuit, which damaged the teeth, and so interfered with proper mastication. By way of remedy, yeast cake and flour were issued, and the men started baking operations in field ovens, the latter being easily made of sods cut out of the veldt. The bread which resulted was in nearly every case heavy, sour, and generally undesirable. Either the men had not the necessary skill for the manipulation of the yeast, or else the latter was of inferior quality. Baking-powders were substituted, and the bread that was turned out left nothing to be desired. The question of the men's teeth on service is, needless to say, a very serious one, and as it is intimately associated with the continued issue of biscuit, the subject of bread-making is one of very high importance.

Another method of making bread is by forcing carbonic acid into the dough. Bread produced by this method is generally known as 'aerated.' It is light and palatable, but does not appear to be so well adapted for general use as bread made by other means.

Wheat is subject to a variety of diseases which are too numerous to be recapitulated here, and an account of which may be found in textbooks on public health. A very good

opinion as to the quality of any sample of flour may be gained by simple inspection, and in the majority of cases, on service at least, there is no necessity whatever for detailed analysis. This is a fortunate circumstance, as the opinion of a laboratory expert is not always to be obtained. Wheat flour should be white, or very faintly yellow; it should not contain any lumps, or any such should break down easily under the slightest pressure; and it should not be acid to either taste or smell. If it can be examined microscopically, so much the better; it can then be seen to consist of grains of different sizes (Fig. 30). The largest are round and are about $\frac{1}{1000}$ inch in diameter, the smallest are mere specks. Intermediate forms are rare. Indistinct curved lines and a linear hilum may be detected on the large grains if carefully

FIG. 30.—WHEAT STARCH, SEMI-DIAGRAMMATIC.*

looked for under a very high power, while the small grains are seen to be angular.

In examining bread as to its fitness for issue as rations, attention should be particularly directed to taste and smell; acidity in either case should certainly entail rejection. The colour of the crumb should be white; if pressed down with the hand, a new loaf should rise when the pressure is removed. The loaves should be permeated with small cavities. Any part of the bread from which these are absent is sure to be heavy, and therefore undesirable as food. In certain stations, notably in India, baking is carried on in military bakeries, and, as in the case of dairy produce and meat, already mentioned, the system presents obvious advantages in regard to inspection.

* The large grains are not round enough.

The opinion of the medical officer is occasionally asked with reference to butter. Besides an ordinary common-sense examination, the only method of detecting adulteration, in the absence of special chemical apparatus, is by the microscope. There is a certain uniformity in the globules of butter, which is not the case with fats used for purposes of adulteration. The globules of margarine, a common adulterant, vary greatly in size.

Coffee is very frequently adulterated, especially on service. There is reason to believe that a good deal of the coffee issued in certain districts in South Africa was largely composed of ground mealies—in other words, Indian corn. A ready test for the most usual form of adulteration is to drop some of the suspected substance into water; coffee floats, chicory sinks and imports its colour to the liquid.

Canteen supplies require careful and constant supervision. The tins should be carefully inspected from time to time, and in all cases immediately after they are received. All those that are bulged outwards, or emit a hollow note on percussion, should be rejected; also those that are rusty or not hermetically sealed.

The date of canning should be clearly stamped on every tin. A very exhaustive investigation of the tinned meat supplied to the army has been carried out by Major W. W. O. Beveridge, D.S.O., R.A.M.C. Major Beveridge finds that the blowing of tins is due to the development of spores of microbes (*Bacillus cadaveris*) which were present at the time of packing, and were not destroyed by sterilization. The lowest temperature of the surrounding fluid which will completely sterilize the tins within a reasonable time is 120° C. (248° F.), and this temperature must act for not less than sixty minutes.*

It is well to remember that 'no bulging' does not necessarily guarantee fitness for issue.

Eggs for the hospital are commonly tested by placing them in water to which salt has been added. Bad eggs, under these circumstances, are supposed to float. I have a

* Report of Committee on Physiological Effects of Food on the Soldier (*Journal of the R.A.M.C.*, June, 1909).

fairly extensive experience of this test, and I believe it to be valueless except in cases of advanced putrefaction. The light test, without being altogether reliable, gives far better results. The test is carried out by holding the eggs against the light, when stale eggs will be found transparent at the upper extremities, and fresh eggs towards their centres. Supplies from sources under military control would obviate the annoyance and disputes which arise from such matters.

Aerated waters are favourite forms of beverage amongst all ranks—a fact which emphasizes the importance of guarding consumers against possible danger. Manufacturers commonly give a discount on returned empties, and the purposes to which these empties have been at times applied, render the advantage of such an arrangement, to anyone but the original vendor, exceedingly doubtful. I have myself seen a bottle of this kind used for conveying urine to the hospital, for purposes of examination ; and as some manufacturers pay for the empties being returned from any source, no matter how suspicious, the attendant risks are obvious. I have also known these bottles to be washed in water from what was little better than a sewer, and it has also come under my knowledge that they are constantly sent back from hospitals without any form of disinfection. It is no uncommon sight in native bazaars, and elsewhere, to see men drinking out of the mouths of the soda-water bottles; and the latter, in the case of native manufacturers, run an excellent chance of being refilled without being washed. The association of this practice with certain affections of the lips, mouth, and tongue, is too intimate to be pleasant. In addition to the above, the water used in the manufacture may be obtained from the most doubtful sources, and as the periods during which certain deadly organisms survive under these circumstances are far from certain, it is well to provisionally accept the serious danger which may constantly arise. Soda-water factories are now happily, to a great extent, under the control of military authorities, and the arrangement is one which should be universally adopted.

A few years ago I examined various samples of aerated

beverages from a popular denominational institute started by philanthropic enterprise for the benefit of soldiers, and found that the water employed in the manufacture must have been obtained from a very suspicious source, yielding as it did marked quantities of nitrites and free ammonia. The analysis was carried out at the request of the president of the committee of management, who, in a thoroughly liberal and enlightened spirit, was anxious to detect and rectify any hidden defects in the institution.

I would here also briefly draw attention to an investigation carried out by myself at Devonport in the summer, 1907. An outbreak of enteric fever had occurred in a militia battalion under training, and twenty-four bottles of 'minerals' were sent to me for examination by the medical officer in charge of the unit. In every case the contents were sterile; the supply, it may be stated, had been obtained, for the canteen and the messes, from a first-rate firm. About the same time I made a series of observations in regard to the vitality of the typhoid bacillus in aerated waters, and the general conclusion arrived at was that it perished in the course of a few days if introduced with other fæcal germs in the form of an enteric stool, but that in pure culture it could survive a fortnight. The experiments were too few to justify an absolute opinion, but in view of the importance of the subject, this reference may be of interest.

In 1903, a report on the manufacture of aerated waters in London was drawn up by Dr. Hamer, Assistant Medical Officer of Health, L.C.C. In submitting this report to the Council, the Medical Officer of Health, Sir Shirley Murphy, states that 'it is difficult to estimate how far the possibilities of contamination referred to by Dr. Hamer can be regarded as constituting a serious menace to the health of aerated water drinkers.'

Clearly, in our present state of knowledge, mineral-water factories for the supply of troops should be subject to active supervision.

In the matter of foods the medical department might with advantage be consulted before contracts are made.

Experience in South Africa was of great value in gauging the methods adopted by certain enterprising firms for the purpose of securing the acceptance of their goods by the military authorities. Speaking from my own impressions, the field supplies were, with few exceptions, of the most excellent quality, and inferior goods had a poor chance of introduction amongst the troops. There were, nevertheless, certain articles which a medical officer with the most elementary knowledge of food examination would unhesitatingly have condemned. Special knowledge was available, but its services do not appear to have been called into requisition at the very time that such services were most urgently needed, and the fact that food was usually excellent, while reflecting the highest credit on the supply department, does not affect the general principle that samples for contract should be submitted for examination to those who are best qualified to express an opinion as to their excellence. To ascertain from a laboratory expert that a sample of food, for which a contract already exists, is unfit for issue, is just about as consoling as to discover that a horse which has been purchased and paid for is hopelessly unsound.

Food on Service.

It is a matter of common experience and common sense that men doing hard physical work require more food than those less actively employed. To go back to the comparison of the engine, we may say that if you want heat, you must use fuel. We have already seen that there is no reason to believe that the body itself wastes rapidly from exercise—some waste will most certainly take place, but this can be easily made good; we can therefore safely come to the conclusion that the meat ration in the field is fully adequate to the soldier's wants (see p. 296).

Of all fuel foods, one of the most valuable is sugar, and the jam ration in the field is therefore more important than might appear to be the case at first sight. The researches of Lee have shown that muscular fatigue is in part caused by loss of carbohydrate material. Lee's experiments were made

on cats; he administered large doses of phloridzin to the animals, and it was observed that the latter after the administration rapidly lost muscular strength, and passed large quantities of sugar in the urine: this condition was caused by the fact that the drug had robbed the body of carbohydrate material, and by administering a carbohydrate, in the form of a sugar known as dextrcse, the muscles regained their natural power.* V. Harley has also investigated the effect of sugar on removing muscular fatigue, and without going further, we may accept the fact that his observations corroborate the theory that fatigue is partially due to the loss of carbohydrate material from the muscles. Herein we may find an explanation of the amount of jam that is consumed in the field. My own experience is that it is a thoroughly popular ration, the reason of its popularity being that it supplies one of Nature's pressing wants. Sugar is issued in the Japanese Army as a ration, its value being recognized by the authorities. Sugar has an advantage over other members of the carbohydrate group in that the latter must be converted into the above named, by the digestive process, before they can be of use to the economy.

Another food of great value is cocoa: not only is it an excellent fuel, but it is also a stimulant without evil after-effects.

Tea has practically no value as nourishment, and the same may be said of the majority of soups; but they are both of value from their stimulating effect, and by acting as accompaniments to other articles of diet. The value of lime-juice, fresh vegetables, and fruit as preventatives of scurvy is well known.

On examining the scale of rations of different armies, it is noticeable that the war rations comprise, as a rule, an increase of protein food over that contained in the peace ration. Judging by the light of the physiological facts referred to (see above and on p. 296), it might almost have seemed better judgment to have limited the increase to carbohydrates and fats, especially the former. It

* *Lancet*, November 9, 1901.

would certainly be presumptuous to dogmatize concerning a highly controversial subject, but it may not be out of place to suggest that the question of the amount of protein consumed by the soldier in its influence on staying-power presents a wide and practical field of investigation. With the recent expansion of our military system, and the amount of willing material which would probably be available, an extensive experiment of national value is not beyond the bounds of possibility.

Food to be of value must be digestible, and palatability helps digestion; everyone knows that a flow of saliva is produced by a savoury smell, and the saliva being one of the digestive juices, Nature thus provides what is required at the appropriate time. An exhausted man may be unable to consume an unpalatable meal, or to assimilate it even if he succeeded, but if presented in an inviting form, the food itself will provoke to action the natural means of digestion. A piece of cold 'bully' beef given to a tired man may not only be useless, but actually harmful, for if the man cannot digest it, the result is unwholesome fermentation, and a disordered condition of the alimentary tract, thus opening the door to a host of other dangers, notably dysentery and enteric fever. Man carries in his interior a laboratory which, if unskilfully supervised, can produce compounds highly prejudicial to the owner, and the supervision of this laboratory is a *sine qua non* for the maintenance of efficiency in the field. Whatever the theoretical value of food-stuffs may be, there is no value attaching to that which cannot be digested, and digestibility is closely connected with palatability and variety. To insure the two latter advantages, a portable field cooker has lately made its appearance; it was designed by Lieutenant and Quartermaster Sykes, Royal Irish Fusiliers, and is claimed to effect the following results:

'1. The cart is capable of cooking a dinner for 1,000 men.

'2. It cooks on the march in any sort of weather.

'3. Only one man is required to attend it once the cooking commences.

'4. There is no smoke or smell.

'5. It bakes, boils, grills, and fries.

'6. Its actual weight, without the food, is only about 12 cwt.

'7. No matter how rough the road, it cannot spill.

'8. It carries its own fuel for the day, which is regulated at will.

'9. It is made in two sizes, the smaller one cooking for about 300 men.

'10. From all cold it will bring to the boil 100 gallons of water in half an hour in the open.

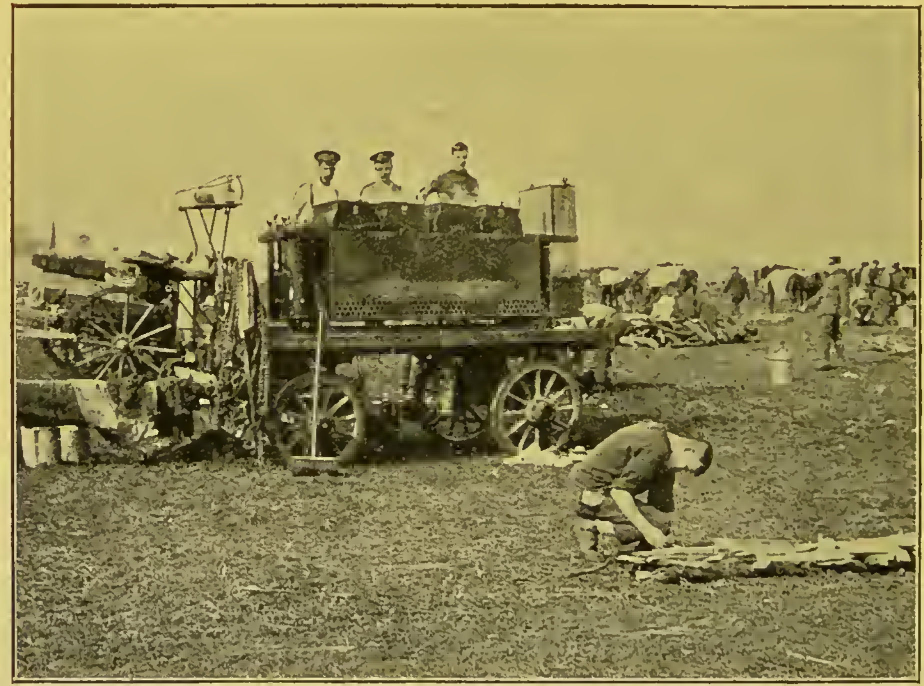


FIG. 31.—'SYKES' COOKER IN THE FIELD.

Photo by Gale and Polden, Aldershot.

'11. At any corner of the road or halting-place, or lullin the operations, the cart can draw up with your men's dinner cooked. They need not wait one minute on arrival in camp; the dinners will arrive with them ready cooked.

'12. The fires are invisible.

'13. A fight may last a week, but still the men can have their dinners and hot food so long as the rations are forthcoming.

'14. There is no delicate mechanism or parts to get out of order, and no chance of failure.

'15. It is equally useful as a stationary cooker in the barracks.'

Fig. 31 shows the cooker at work in the field, and Fig. 32 gives an idea of the internal arrangement.

If the design can effect all that is claimed for it, we shall have at our disposal a potent means for banishing those intestinal disorders which, forming as they do an almost

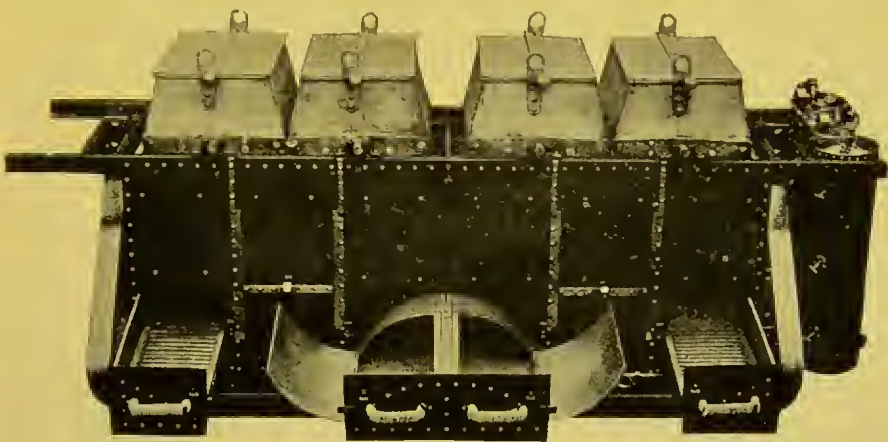


FIG. 32.—GENERAL SCHEME OF 'SYKES' FIELD COOKER.
Photo by Lime Valley Engineering Company.

invariable accompaniment of war, are a menace to national security.

FOOD-POISONING.

Food-poisoning may result from the presence of poisonous metals, but this is certainly not a common form of the danger. Arsenic, antimony, lead, tin, and copper have all come under suspicion. The first undoubtedly caused a widespread outbreak of poisoning, a matter which will be further considered in the chapter on Alcohol. Antimony has been found in the rubber rings round the interior of the necks of soda-water bottles; it is believed to have caused symptoms of poisoning, but the danger must be so slight that for practical purposes it can be discounted altogether. Lead has been found in beer and cider; the acid present in

either of the above can dissolve dangerous quantities of the metal if contact is prolonged. One of the earliest recorded cases of poisoning from lead in beer is that of a workman, in London, who stopped every morning to refresh himself at the same public-house; being the earliest customer, he was served with the beer that had been in the pipes all night, and the liquor, by the quantity of lead it contained, ultimately caused the man's death. I have latterly seen a patent form of jointed pipe in the canteens I have inspected, and this design is stated to be an absolute protection against the danger in question. It is sometimes stated that lead-poisoning can result from the practice of cleaning out decanters with shot. Tin and copper are possibly causes of poisoning, particularly in the case of tinned fruits, but the risk is too slight to form a serious ground for apprehension.

The most serious forms of food-poisoning are caused by bacteria, and may be divided into two broad classes:

1. Those cases which result from bacteria swallowed with the food, and producing poisons within the body.

2. Those cases which arise from poisons manufactured by bacteria in the food prior to the consumption of the latter.

The first form is the more dangerous, and probably the more frequent of the two. One of the most important outbreaks occurred at Frankenhausen in 1888. In this case the meat appeared perfectly good to naked-eye examination, and was free from unpleasant taste. It transpired that the cow which furnished the meat had suffered for some time from persistent diarrhœa, but, with the exception of some reddening of the intestinal mucous membrane, the carcass showed no signs of disease. From a case which ended fatally Gaertner isolated a bacillus which now goes by his name—viz., the bacillus of Gaertner. The importance of this outbreak is found in the fact that, by his researches conducted at the time, Gaertner has helped greatly in placing our knowledge of food-poisoning on a sound basis.

The organism isolated by Gaertner is one of the typho-colon group, and it is a matter of common knowledge that food-poisoning is sometimes indistinguishable from

what is known as 'enteric fever.' It is now widely held that the bacilli most frequently responsible for meat poisoning can be divided into two main classes: (1) the *B. enteritidis* of Gaertner, just named; (2) the *B. paratyphosus B.*

A most instructive outbreak occurred at Gibraltar in 1908, as the result of a Christmas dinner at the dockyard. Sixty-four men sat down to the dinner, and out of this number twenty-five were attacked so severely as to necessitate admission to hospital, and others suffered to a minor degree. The onset occurred from three to seventy hours after the dinner, and showed itself by vomiting, diarrhœa, headache, pains in the limbs, fever, and marked depression. The origin of the outbreak was investigated by Staff-Surgeon Daw, R.N., and Staff-Surgeon Hall, R.N., and the viscera of a fatal case were sent to Major C. E. P. Fowler, R.A.M.C., and Mr. Abrines for examination. From the contents of the stomach and intestines, and from the blood-drippings, *B. paratyphosus B* was isolated. Without entering into any discussion as to the close relationship of the above organism with the *B. enteritidis* of Gaertner, the fact remains that the geese had come out from England in cold storage, and had not been 'drawn,' and the intestinal germs had, of course, travelled with them; and putting aside minor differences, we may say, without fear of contradiction, that it is the typho-colon group, as indicated above, that we have the most reason to dread in connection with food. As affecting the particular case in question, Major Fowler, in his excellent report, writes as follows: 'In what manner the birds were affected it is difficult to say. It is probable that two of them out of the six had suffered from disease before slaughter, and, being undrawn, the bacilli had multiplied, invaded the flesh, and formed their toxin, which would account for the acute onset in several of the cases.'*

This outbreak is particularly instructive in that it furnishes an example of each of the categories named above—the rapid onset points to an already existing poison, the delayed onset to the manufacture of poisons by the germs which had been swallowed. It must be plain that if the

* 'Outbreak of Food-Poisoning after a Christmas Dinner,' by Major C. E. P. Fowler, R.A.M.C. (*Journal of the R.A.M.C.*, September, 1909).

poisons only are in question, the outlook must be brighter than when living germs are at work. In the former case once the poison has been eliminated from the body, no further fears need be entertained; but the issue is doubtful when we have to deal with bodies that can exist within us indefinitely, and work to our physical detriment at the same time. It has been contended that poisoning by the poisonous products of bacteria, and without the bacteria themselves, never occurs. In support of this contention, it has been argued that it is inconceivable that all the germs would die off and leave only their products in the food; but, on the other hand, it is easy to see that germs may either be killed by cooking or by the digestive juices of the body, while the poisons in either case might remain unaffected. Of course, the two forms of poisoning may coexist.

We must, however, remember that cooking is not a complete safeguard against food-poisoning bacilli, and it is not difficult to see that it cannot be a safeguard against their poisons. An outbreak illustrative of the former fact took place on November 3, 1908, at a Roman Catholic industrial school for girls at Limerick. Out of 197 girls, 73 were attacked, and 9 died. At noon a meal of second-warmed beef was served to the scholars, and at 6 p.m. on the same day an alarming attack of illness, in the form of acute gastro-intestinal disturbance, had broken out. The short interval in some cases between the meal of second-warmed beef and the attack pointed to the presence of existing poisons, but the isolation of the *B. enteritidis* of Gaertner from five of the cases proved the agency, also, of a living germ. Dr. E. J. McWeeney, Bacteriologist to the Local Government Board for Ireland, to whose courtesy I am indebted for a copy of his interesting and valuable report, states that he 'could find no constant morphological or cultural difference between this strain of Gaertner's bacillus and the paratyphoid β bacillus.' In this case the meat had not only been cooked, but had actually been cooked twice, although it is possible that it may have become infected after the last cooking.*

* 'Observations on an Outbreak of Meat-Poisoning at Limerick,' by E. J. McWeeney, M.A., M.D. (R.U.I.), *British Medical Journal*, May 5, 1909.

Having regard to the above outbreaks, it is clear that early occurrence is no guide as to likelihood of a favourable or other issue, but that later occurrence is certainly of serious import.

A case of what I believe was poisoning solely by bacterial products occurred at Springfield Bridge during the retreat of the Ladysmith Relief Column after the engagement at Vaal Krantz. The force was practically subsisting on preserved food, which, for purposes of convenience, was largely carried in small tins. An officer who had partaken of the contents of one of these tins, consisting of meat, vegetables, and gravy, was almost immediately attacked by violent pains in the stomach, vomiting, and diarrhœa. The pain was intense, the vomiting and diarrhœa persistent, and the patient delirious. Within twenty-four hours the diarrhœa and vomiting had ceased, the temperature was subnormal, and, except for some weakness, the officer was practically well.

A case of somewhat the same nature as the above occurred at St. Helena in 1897. The men of the detachment of the 1st Leicester Regiment purchased a large quantity of mackerel—or, rather, of a fish known locally by that name—which was cooked and eaten for breakfast. As there was considerably more of the fish cooked than the men required, the unconsumed portion was set aside and eaten at supper, having been left during the day in the veranda, where it was exposed to the full glare of the sun and to pollution by dust. Several men partook of this unwholesome residue about 8 p.m., and were almost immediately seized with vomiting, diarrhœa, and gastric pains; dryness of the throat and subsequent dilation of the pupils were also notable symptoms. There were no urgent signs of collapse; and several of the men managed to drag themselves to the hospital, which was a mile distant, without waiting for the transport that I had ordered. Within forty-eight hours all the men were out of hospital, and apparently none the worse for their unpleasant experience. This was clearly an instance of chemical poison manufactured in the fish during the time it lay in the barrack veranda. The fish itself, as I know from experience,

is, like most other St. Helena products, excellent when eaten under common-sense conditions.

At Colchester, in 1886, a young soldier partook of a supper of cockles just before returning to barracks at 10 p.m. He was violently sick during the whole night, the sickness being accompanied by profuse diarrhœa, and had, as far as could be ascertained, suffered great pain. He did not, however, report sick. In the morning, apparently feeling better, he got up to wash himself, and instantly fell dead by the side of his cot. In this case the poison had probably been got rid of by the vomiting and diarrhœa, but it had so far weakened the heart that the effort of rising from bed produced fatal syncope. I was unable to ascertain the length of interval between the time that the fish had been eaten and the onset of the acute symptoms, but, as far as I could gather, it must have been about half an hour. This was probably a case of poisoning from substances already formed in the fish, as the evidence went to show that the soldier had consumed the semi-decomposed residue of what had been lying on the barrow all day. Persons who had partaken of the fish when it was fresh suffered no ill effects. The case illustrates the necessity for keeping the patients at rest after all urgent symptoms have disappeared.

An officer who had partaken of devilled sardines overnight, was seized at 2 p.m. on the following day, with symptoms not unlike those detailed in connection with previous cases, but with certain important exceptions. The signs of collapse were of great urgency, the patient being almost pulseless, with subnormal temperature and cold extremities. At the beginning of the attack there were violent pains in the head, but this was shortly followed by partial loss of consciousness. For several hours death from collapse was imminent, and restoration to health was not of the rapid and complete nature which accompanied cases already recorded. Careful investigation of the articles of food consumed in the mess left no doubt as to the cause of the trouble.

I should feel disposed to regard this attack as one in which the poison had been slowly produced by bacteria, after the

food had been swallowed, but not of the nature of a general infection.

The chance of poisoning from preserved preparations is one to which officers and men are peculiarly exposed ; but apart from risks of this kind, the whole question of the examination of articles of food is evidently closely related to the duties of medical officers. All cannot possess knowledge of methods of minute analysis, but in the light of previous training and ordinary common sense a good working opinion can generally be arrived at. The value of such an opinion, notably in the case of contracts, cannot be doubted. In India, where medical officers are constantly consulted concerning the formation or renewal of contracts, the time previously spent in the acquisition of practical knowledge in this direction is not likely to be regretted.

The soldier is always liable to be the ready victim of unscrupulous private enterprise which, by fostering sickness and inefficiency, is a source of danger to individuals and of detriment to the State.

Until within recent years poisoning by food was generally attributed to 'ptomaines,' a ptomaine being an animal alkaloid, or, to be exact, a derivative of ammonia, NH_3, in which part or all of the hydrogen has been replaced by an organic radicle. We now know that the poisons commonly produced are of a far more complex and diverse nature than the ptomaines aforesaid ; they are classed under the generic heading of 'toxins,' and, as we have seen, are often of a sufficiently deadly nature.

In the light of the above facts, the steps to guide us in protecting the health of troops are :

1. Careful examination of the carcasses of slaughtered animals, or, better still, examination of the animal prior to slaughter. It should be remembered that the cow which caused the Frankenhausen epidemic was suffering from diarrhœa, but that no other signs of illness were detected beyond some intestinal congestion, and yet the results were disastrous.

It is certain, therefore, that apparently mild forms of sickness in animals should arouse grave suspicion.

2. Prevention of contamination of the carcass either in the slaughterhouse, meat - store, or elsewhere. In ill-managed slaughterhouses intestinal germs abound.* Any ill-ventilated and badly-constructed meat-store should not be tolerated in the service. It is certain that decomposing meat may infect fresh meat near it.

3. Efficient cooking. Individually these precautions may fail, but collectively they should insure a reasonable degree of safety as regards the ration meat of the soldier. There is one form of poisoning believed to be caused by bacterial toxins, existing as such, in the food, to which some reference must be made. It is known as 'botulism,' the causative agent being the *Bacillus botulinus*. The condition was originally investigated by Van Ermengem, on an occasion of an outbreak of poisoning at Elezelles, in December, 1895. The outbreak was in part traced to a ham and in part to sausages, and since the above date many cases have occurred in which the latter form of food-stuff was found to be the origin of like mischief. The symptoms, which commonly appear almost immediately after the food is eaten, consist of vomiting, pain in the epigastrium, constipation, and a remarkable paralysis of the eyeball, accompanied by squint, double vision, or actual blindness. The mortality is sometimes as high as 40 per cent. Strange to say, the affected meat is often unaltered as regards taste, smell, or appearance. The mischief is likely to be associated with what may be called 'disguised offal,' and although practically unknown in England, the bare possibility of its occurrence should suggest watchfulness in regard to certain mysterious articles of diet which are sometimes seen in regimental institutes.

* See Further Report upon the Presence of the Gaertner Group of Organisms in the Animal Intestine, by Dr. Savage, Appendix B., No. 5, Annual Report of the Medical Officer of the Local Government Board, 1908-1909.

Dangers in India from Habits of Natives.

Reference may here be made to the necessity of insuring cleanliness on the part of natives of India who are called upon to handle food.* There is no denying the fact that the habits of the average native of the lower class have little to recommend them on the score of cleanliness. Washing the person, as understood in England, is unknown, and soap seems to be a rarity. A few drops of water sprinkled from a small brass bowl, just sufficient, probably, to spread the dirt over a wider area than that which it previously occupied, often take the place of a thoroughly satisfactory ablution. From time immemorial in the East water has been the invariable cleansing agent used after certain acts of Nature. As the water is applied with the hand, and soap is not used afterwards, some idea may be formed of the filthy possibilities present on the persons of the lower stamp of native servant.

Men to whom the word cleanliness is absolutely unknown, in its true sense, are employed in bakeries, kitchens, dairies, and soda-water manufactories. The above are, fortunately, in military life, placed under European and official control. The excellence of the principle contained in this arrangement is too evident to call for discussion; it only remains to be seen that the control is effectual from every point of view. Personal experience leads me to believe that it is so, but to maintain effectual control necessitates unrelaxing vigilance. No doubt there are cases of lack of proper supervision, and at inspections things are always seen at their best, although even at surprise visits I have, with one exception, found nothing to arouse a suspicion of carelessness. What, however, appears to be wanting is a uniform code of rules to apply to all institutions in which articles of food or drink are prepared by native labour. Among any such rules the following might well occupy a prominent place:

1. That no native should be allowed to enter any kitchen,

* See chapter on Routine Duties.

bakery, etc., for the purpose of carrying out any duty connected with the preparation of food, without changing the clothes which he has been wearing outside.

2. That special clothing should be provided for natives while engaged in the work of the nature now in question.

3. That the clothing provided for this purpose should never be removed, except in the way of duty, from a place specially set apart for its safe-keeping.

4. That before beginning any of these duties, the whole person should be thoroughly cleansed with soap and water, as, in view of the extent of the body which low-class natives habitually expose, and which is often foul in the extreme, nothing short of complete ablution is satisfactory.

In the district laboratory at Meerut I made certain experiments with a view of ascertaining how far baking was likely to insure the absence of germs in native-baked bread. The method adopted was simple in the extreme. The loaf was cut in half with a sterilized knife, the crust having been previously sterilized in a flame. Thin slips of bread were then cut from the interior, held in sterilized forceps, and sown in various nutrient media. Although up to the present I have been unable to make any observation on the effect of baking on individual germs, there is no doubt that the process does not sterilize. It is true that I have never succeeded in detecting forms indicative of fæcal contamination, but the possibility of such surviving is beyond question. The distance to which the sterilizing effect of the heat penetrates into the loaf is uncertain, and probably varies with the consistence of the dough and other conditions, notably temperature. Exact knowledge would be of value, as safety might be attained by diminishing the size of the loaves.

In India, the European must realize the fact that his food, his drink, his eating utensils, his cooking utensils, his clothing, and, in fact, his belongings generally, are habitually handled by beings who are in a chronic state of excremental pollution. There is no question concerning the value of sanitary measures, but until time and education have eradicated

the ignorance, the prejudice, and the superstition which have descended from the very dawn of history, and which are ingrained by heredity in the lower strata of the population, so long will the wisdom of health administrators fail in producing those results which are found to follow, from a like cause, among the nations of the West.

CHAPTER XVII

CLOTHING

To make clear the broad principles which underlie the subject of clothing, it should be explained that all bodies are endeavouring to arrive at the same temperature, the consequence being that the hotter bodies are steadily giving off heat in favour of those that are colder, and as the surface of the human frame is, as a rule, warmer than the surrounding air, we should, in the absence of clothing, be subjected to a serious loss of animal heat. If the temperature of the body is below that of its surrounding medium, the current of heat is naturally in the opposite direction.

The clothing issued to the British soldier may be divided, for purposes of sanitary classification, into two headings—viz., woollen articles and cotton articles. Under the former heading may be placed the silver-grey flannel shirt, the cardigan waistcoat, and the flannel drawers served out to infantry.

The latter heading comprises the cotton drawers issued to mounted troops, and the khaki drill which is in general use, with scarcely an exception, in all stations abroad.

Great-coats, tunics, frocks, and trousers are of somewhat uncertain composition, and the same may be said of the khaki serge of which many articles of uniform are now made.

It is well to draw a rigid line of distinction between the two main classes referred to above, and the essential differences regarding them should be constantly borne in mind. Wool,

as an article of clothing, renders to man those services which Nature designs for certain members of the animal creation. The value of this material as a covering is due to two principal qualities: firstly, that it is a bad conductor of heat; secondly, that it is able to absorb large quantities of moisture. By means of the first of the above it checks the loss of heat which tends to take place from the bodies of all animals, and at the same time it acts as a protection by equally checking the passage of excessive heat from the exterior to the surface of the skin. This low conducting power of wool is due partly to the animal fat within its substance, and partly to the presence of air entangled between its fibres, air having, as is well known, comparatively low powers of conduction. By means of the second of the above properties wool is able to absorb the perspiration from our persons. In the absence of woollen clothing perspiration would be rapidly evaporated, and a corresponding quantity of heat would disappear, or, in the language of science, become latent. In other words, heat which is employed in maintaining moisture as vapour cannot at the same time make itself perceptible to our senses; to use a commonplace expression, it is 'otherwise employed.' The heat necessary to maintain the perspiration in the form of vapour is taken from the nearest and most convenient source—viz., the animal body. The value of flannel or, what is the same thing, of woollen clothing, during and after exercise is a matter of general knowledge. The perspiration, being held as moisture in the fibres of the flannel, is prevented from evaporating, and loss of heat from the body is checked by the low conducting powers of the material. These advantages are not possessed by cotton or linen; the fabrics in question, being of vegetable origin, are not formed of material which, under natural conditions, fulfils the particular purposes of utility which, as we have seen, apply in the case of wool. Neither cotton or linen can hold moisture to any material extent, and they therefore allow the rapid evaporation of perspiration, with the attendant danger of chill. Both fabrics are comparatively good con-

ductors of heat. A cotton or linen shirt is undesirable as an article of dress if worn next the skin in either cold or hot weather. In cold weather it conducts away the heat from the surface of the body to the external air, and in hot weather it is only a slight protection, as it allows the heat of the solar rays to pass in the opposite direction.

There is a form of clothing which appears to be extensively sold under the name of 'cellular cotton cloth.' Air is contained between the fibres of the material, and as the first named is, as previously noted, a low conductor of heat, this fabric is likely to be warmer than other kinds of cotton cloth.

Khaki drill is actually cotton, and those who have used it on service are well aware of its disadvantages. It is an inferior protection against either heat or cold, and when wet with perspiration it favours free evaporation, and is consequently productive of serious danger of chill. Flannel would undoubtedly cost more, but it is probable that the increased expense would receive full compensation in increased efficiency. Flannel, however, possesses certain disadvantages in the direction of washing. Its qualities are due in part, as already stated, to the animal fat contained in its substance, and this fat is removed if the material is exposed to the action of boiling water, or if it is repeatedly washed with inferior soaps containing an excess of alkali. Army washing is not always carried out with careful regard to the nature of the articles subjected to the process. I have heard men complain that after a few washings their flannel shirts become hard and stiff. This is probably due to the use of coarse soaps, or to the shirts having been thrown, with other articles, into a washing receptacle containing water somewhere about the boiling-point. Flannel should always be washed in tepid water, and the better forms of soap should be used. A little paraffin is stated to act well in removing the dirt. Violent wringing or rough handling, during the process, seriously damages flannel. The Indian dhobi is generally an abominable washerman. It is no uncommon thing to see clothes being violently beaten on

stones, a process destructive of all fabrics, and notably so in the case of flannel.

In addition to the absence of all ordinary skill and care, the washing is carried out in any dirty stream that may happen to suit the native's idea of convenience. I once saw clothing, belonging to what was considered a respectable hotel, being washed in little better than a filthy drain flowing straight from the native quarter. In Delhi nearly all the washing is carried out in the Jumna, a stream which, in the neighbourhood of the city, is horribly foul. There is no doubt that handkerchiefs and other articles of intimate use have been subjected, in the so-called process of washing, to what is in reality soakage in water polluted with unnameable filth. Besides the unspeakably disgusting suggestions awakened by such an association as the above, the dangers attendant on this disregard of sanitation must be of a most pressing nature, and it is no far-fetched idea to accept the possibility of the spread of cholera, dysentery, enteric fever, and other diseases by these means; and the subject is in consequence fully worthy of the earnest attentions of official authorities, and, in fact, of all European residents in India. Perhaps, in the not far distant future, properly equipped laundries will be considered essential in every cantonment.

It is quite a simple matter to detect either cotton, linen, or wool by means of the microscope. The fibres of the two former should first be well macerated in water, and teased out with a needle; they can then be placed on a slide and a cover-slip applied; the excess of water should be removed with a small piece of blotting-paper. The fibres of cotton are thin and flattened, and they have a very well-defined margin; the characteristic feature, however, by which they should be detected is that they are invariably twisted (Fig. 33). The fibres of linen are jointed, and if carefully teased out are seen to be composed of fibrillæ or elementary fibres which go to make up the main fibre. Wool fibres should be placed in dilute soda before mounting. The fibres of wool are rounded, with cross markings and notched margins (Fig. 34).

The desirability of wool as an article of clothing for military

service is sufficiently obvious if the nature of the substance is understood, and the value of the cholera belt is at the same time apparent. Experience in South Africa goes some way to show that the chilling of the legs, due to the use of khaki trousers, when the limbs are saturated with

FIG. 33.—COTTON FIBRES, SEMI-DIAGRAMMATIC. × ABOUT 200.

perspiration at the end of a march, and the consequent congestion of internal organs, are common causes of dysentery, diarrhœa, and perhaps of enteric fever. The above possibly furnishes the explanation of those cases of diarrhœa which constantly occurred 'on trek,' without any assignable cause.

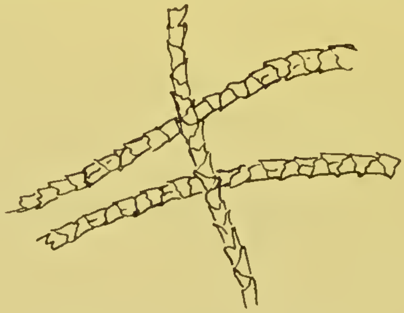


FIG. 34.—WOOL FIBRES, SEMI-DIAGRAMMATIC. × ABOUT 200.

This question certainly deserves serious attention, as a disordered condition of the alimentary canal, without doubt, predisposes the soldier to troubles of the gravest nature.

Drawers are now issued to recruits, cotton being the material used for mounted corps, and wool for the infantry.

As concerns the latter, it is rather doubtful whether the articles would be the most suitable, owing to their thickness, for general use in hot weather. The wearing of these garments should, in spite of the above defect, not be neglected, and steps should be taken to see that they are properly washed. The latter point may seem rather a paltry detail, but it must not be considered as such if it conduces to efficiency, and there can be no reasonable doubt as to its doing so. Socks for men should always be of wool; cotton socks constantly cause blisters.

Whether waterproof clothing will ever come into general use for military purposes is still an open question. Major E. L. Munson, in his admirable work on Military Hygiene, gives a detailed account of what appears an efficacious and rapid method of rendering uniforms impervious to wet. The process consists, essentially, in saturating the articles with wool fat. It seems to present no particular difficulty, and it would seem desirable that its efficiency should be thoroughly tested in our army. The great objection to waterproof clothing is contained in the fact that it stops the passage of moisture, and therefore impedes evaporation from the surface. The heat and discomfort caused by the prolonged wearing of a mackintosh are sufficiently familiar, but Major Munson's scheme seems free from this disadvantage.

Boots are articles which should not escape the attention of the medical officer. In general terms a boot consists of the following parts:

1. The 'counter,' or the portion which surrounds the heel.

2. The 'vamp,' or portion covering the toes.

3. The 'quarter,' or lateral portion lying between the vamp and the counter; the vamp and the quarter together forming the 'upper.'

4. The upper sole.

5. The lower sole.

6. The 'welt,' or border of leather which joins the boot to the lower sole.

7. The 'stiffening,' or piece of vertical leather placed in the middle line at the back of the counter. The last named is

more important than might appear at first sight. Complaints have been made that it is too high, and is consequently bent inwards by the lower edge of the putties; it thus forms a thick hard ridge, which chafes the skin over the tendo Achillis, and is a frequent cause of blisters. It has also been stated that the heel of the boot is too full, and allows an amount of movement which is conducive to the above result. The space between the soles is filled with compressed pieces of leather, of various sizes; this forms a hard substance, and new boots issued to the soldier are sometimes found to be uncomfortable. When the boots are re-soled this space is sometimes filled with felting, and the latter being soft and adaptable to the shape of the foot, boots thus re-soled are pleasanter to wear than new ones. If the inner sole is cut too broad, it turns up at the edges and chafes the side of the foot. It is sometimes stated that the present boot does not allow room enough for the toes, and particularly for the ball of the great-toe.

In the Indian pattern there is a 'middle sole,' and between it and the inner sole is the packing. These boots are stated not to wear as well as the English-pattern boot with two soles.

If any intelligence is used in fitting, the army boots generally prove quite satisfactory to the wearer. I have covered long distances in them, over very rough ground, and I have never found the least cause for complaint

A form of boot was introduced a few years ago which appeared to combine the advantages of cheapness and of durability. The sole was fastened to the upper by means of screws, and the boots machine-made. Regimental shoemakers have informed me that the machine employed in the manufacture of the boot worked with such force that the sole was compressed into the consistence of a hard board. Movement at the transverse tarsal arch and at the metatarso-phalangeal articulations was, in consequence, impeded, and the foot had more or less to be lifted as a whole. The men complained that the use of these boots readily induced fatigue, and was productive of blisters.

The old clumper boot, although not particularly sightly, was well spoken of by its wearers. It was simple in construction, and the men could put on new clumps themselves, as the rivets, which were used instead of screws, required no particular skill for successful manipulation.

The pattern of boot issued for foreign service is well liked. It is stated to be strong, supple, and durable. It is also lighter than the boot issued at home.

The ceremonial head-dresses of the British Army are extremely varied and equally unpractical ; but as their divergencies are matters of historic interest, and often intimately connected with regimental distinctions, their value as a means of stimulating *esprit de corps* and maintaining a soldier-like spirit is probably more than counterbalanced by their defects. The slouch hat, which has not been seen of late, was a very practical form of head-dress. It was light, comfortable, soldier-like in appearance, and, as far as home service goes, was an excellent protection against the sun. It has been recommended for use in the Territorial Army. The old field-service cap was hygienically an abomination for hot-weather use.

It has been stated that sunstroke, as distinct from heat-stroke, is caused by the actinic rays of the sun. It seems that the use of orange-red lining to the headgear is a useful protection, this blend of colours being impervious to the actinic rays ; it also seems that the impediment to the circulation caused by the pressure of the edge of the head-dress acts as a predisposing cause of the absorption of the rays. As affecting the question of colour, the experiences of Dr. Andrew Duncan, related by himself, are of great value :*

'In August, 1880, I had returned to India in the rudest health, after six months' sick leave to New Zealand from Cabul. I was sent upon service again immediately, but this time on the Kandahar line. I reached Sibi in the first week in September. What the temperature must be at this place in July is rightly estimated by the saying of the natives in this part of the country, when they wonder why

* *British Medical Journal*, vol. ii., 1902.

the Supreme Being made hell when Sibi was at hand on earth. . . .

'The same week I joined my regiment in the Pislim Valley, and the next day took part in a small expedition. . . . On returning to camp my head was splitting, and I had to be sent at once to hospital. . . . For the next six weeks, however, the racking pain in the head never left me, except at the end of this time in the evening hours. I was then invalided to England, but it was not until I got west of Suez that the headaches ceased. After two years' sick-leave I returned to India. . . . About March, as the hot weather commenced, I was again seized with these distressing headaches, and in the first week of this second onset a temporary attack of hemiplegia occurred. I was invalided to Kashmir for five months. . . . After four months the pains gradually ceased, and I returned to duty. Each succeeding hot weather for a series of years severe headaches now regularly tormented me, but no definite attack of sunstroke occurred until 1887, when I was again the victim of this affection whilst on leave, shooting in the Himalayas. Lastly, in April, 1891, whilst on the Black Mountain Expedition, my last attack occurred, characterized by the same distressing symptoms—namely, an intolerable headache, etc. For this I had five months' sick-leave in the hills, but on returning to duty in the plains, I was again knocked over by the sun, and had to take two years' leave to England. Shortly after my return to duty, I fortunately read a letter in the *Pioneer* newspaper, written by an executive engineer. This officer had suffered on several occasions from sunstroke. Reasoning from the fact that no one gets heat-stroke from the great heat of furnaces in an arsenal, he came to the conclusion that the heat rays of the sun were not the *fons et origo mali*, but the actinic rays. Hence he treated his body as a photographer treats his plates, and enveloped it in orange, using always an orange-yellow shirt, and lining his coat and hat with flannels the same colour. During the subsequent five years of extreme exposure he suffered from no bad effects of the sun. Acting

on this hint, whenever I had to perform a march in hot weather, I always used an orange-yellow shirt; I lined my helmet with orange-yellow flannel, and had a pad of the same colour stitched into my khaki coat down the back. I, too, never again, in consequence, felt the effect of the sun. I would, therefore, submit that the dangerous rays of the sun are the actinic, and as a means of protection from sun-stroke I would advocate the use of such means as I have indicated. As a further precaution, the helmet might be lined with a layer of tinfoil.'

The experiences of Dr. Harold Corbusier, Contract Surgeon, United States Army, corroborate those of Dr. Duncan:

'During service in the Philippines I had an experience which has influenced me to agree with the theory of Dr. Duncan. After considerable exposure to the direct rays of the sun, severe headaches occurred, until one day I wore a khaki cap lined with orange-yellow silk, and noticed that I did not suffer from headache. I then did a little experimenting with this cap and my campaign hat, which I had been in the custom of wearing when in the sun, and found that, whenever I returned to the latter, the headaches would recur with more or less intensity.

'The same immunity could be produced by placing orange lining in the campaign hat, but I did not continue this, as the lining was not made for the campaign hat, and I had no means of fastening it there readily. I have since heard that Europeans in Egypt often wear a jean skullcap under the helmet, and that it is said to lessen the penetration of the rays of the sun. I do not know, however, what colour this skullcap is.'*

In hot climates the khaki-covered helmet appears to answer well, but increased ventilation in the crown is desirable, and could easily be provided. A certain number of apertures in the upper part of the helmet would do all that is required.

* 'Military Head-Gear and the Health of the Soldier,' by Harold D. Corbusier, B.S., M.D., Contract Surgeon United States Army (the *Military Surgeon*, May, 1906).

The khaki serge which is now largely in use, although not altogether sightly, is practical and serviceable; but the putties, or leggings, are not well adapted for medical officers, except in the field or for parade purposes, as the length of time required for adjustment might prove to be a very serious matter in the case of an urgent summons.

The colour of articles should be carefully considered when deciding the question of general suitability. It is well known that different colours are possessed of different heat-absorbing powers. Black has the highest capacity for absorption; white has the least. Unfortunately, white is for many reasons unsuitable to the field. Khaki drill is stated to possess low powers of absorption. 'The order in which different colours absorb heat is as follows: black, dark blue, light blue, dark green, turkey red, light green, dark yellow, pale straw, and white.'*

It is very satisfactory to see the extent to which wool enters into the clothing of the men, and the abolition of khaki drill and the substitution of flannel in its place may not be far distant.

* 'Hygiene and Public Health,' Parkes and Kenwood.

CHAPTER XVIII

REFUSE DISPOSAL

THIS subject may be conveniently divided into two headings —viz.: (1) Disposal of excremental refuse; (2) disposal of refuse of other kinds.

The continuance of terrestrial existence depends, among other things, on the proper utilization of the waste products of organic life. The term 'waste products' is, in fact, a misnomer, for these products, although without doubt harmful if retained in the immediate neighbourhood of human beings, become, when applied to the soil, the means by which nutriment is furnished to the vegetable world, and the maintenance of animal life insured. When these or other kinds of dead organic matter come under the influence of certain living agencies of the soil, they are subjected to a process somewhat resembling what we know of digestion as it occurs among the higher animal forms. First, peptone-like bodies are formed; then leucin and tyrosin; then indol, skatol, and phenol; then sulphuretted hydrogen, carbonic acid, marsh gas, hydrogen, and ammonia; lastly, by combination with the alkaline bases in the soil, the corresponding nitrites and nitrates are formed, the latter being the ultimate stage of the process.

These changes are seen to consist essentially in the transformation of organic into inorganic material. They are due to the work of certain bacterial forms in the soil, which, being aerobic, are only found near the surface. Without the presence of these bacteria the vegetable world would be

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unable to obtain its necessary food-supplies, as organic matter is useless as manure until it has been broken down into its inorganic constituents.

But Nature does not limit her benefits to the cycle of change described above, for not only is offensive matter satisfactorily disposed of in the soil, but the germs which accompany such matter are either destroyed or so far altered as to become innocuous.

Such, then, is Nature's method of sewage disposal.

As civilization advanced, and as large stationary communities came into existence, space became restricted, so that it was found necessary to dig pits for the reception of the excreta; and these pits were the precursors of the modern cesspool. In the poorer districts of large cities even the primitive cesspool was absent, and the inhabitants rid themselves of their refuse by the simple method of throwing it out of the doors or windows. Such a state of affairs was certain to result in disaster, and a frightful death-roll from filth-bred disease, attributed to a mysterious 'Providence,' was among other undesirable accompaniments of the 'good old times.' It was not unnatural to imagine a causal relationship between smells and sickness, so that, before the science of bacteriology attained its present dimensions, absence of what was manifestly offensive was considered a standard of purity and safety, and this fallacious standard lingers among us still.

We have already seen that Nature's method of sewage disposal consists of three distinct processes: (1) The conversion of offensive organic refuse into inoffensive inorganic matter; (2) the utilization of the inorganic matter as food for the plant world; (3) the destruction or modification of disease-producing germs.

We may now see how far modern systems of sewage disposal are an imitation of natural processes. It would lead too far from present purposes to discuss the various systems in detail, and it will therefore only be necessary to refer to certain principles particularly affecting the immediate subject.

The oldest system of sewage purification is precipitation.

This aims at throwing down suspended solids, and possibly some of the organic matter in solution. A large number of precipitants have been used; probably the best known are caustic lime and alum. When the above are added to sewage, interaction takes place, with the formation of calcium sulphate and a precipitate of aluminium hydrate, the latter carrying down suspended matters. The effluent is teeming with sewage germs, and rich in organic matter of considerable manurial value; and unless application to the land is in force, the germs escape destruction, the value as manure is wasted, and the solid matters become a source of general embarrassment. Efforts are made to dispose of the solids as manure, but it is fairly certain that they do not afford much field for profit. In this connection the Royal Commission on Sewage Disposal found that 'none of the sewage sludges used would be worth ten shillings a ton on the farm for wheat-growing purposes.' At the Seventh International Congress of Applied Chemistry, Dr. J. Grossman read a paper in which he suggested that the grease could be removed from the sludge, and a sale of the former made profitable, while the manurial value of the sludge would be raised from ten shillings to twenty-five shillings a ton. A few years previously Dr. Grossman propounded an ingenious scheme for manufacturing fruit essences from the same source.*

Unless one of the above schemes is reduced to practice, we can accept the fact that precipitation is conducive to neither safety nor economy.

Another system is exemplified in the septic tank. It was believed that by confining sewage in a closed tank the anaerobic organisms would, by a process of digestion, liquefy the solid matter, so that the sludge question would be satisfactorily settled. It was likewise claimed that the system destroyed any pathogenic germs which there might be in the sewage. It is now known that the pathogenic germs are practically unaffected, and that only about 30 per cent. of the solids are digested.† There is, however, a

* *British Medical Journal*, May 5, 1905.

† Fifth Report of the Royal Commission on Sewage Disposal, p. 21.

partial conversion of organic into inorganic matter, the ultimate stages of the conversion being effected by the method named below.

The last artificial system to be mentioned—viz., filtration —is often combined with the above, and constitutes the last stage of the process. Sewage filters are of two kinds, contact beds and percolating filters. In the first the sewage is held up before it is discharged. 'The bed, after it is emptied, is allowed to remain empty for some time before receiving the next filling. The length of time during which the sewage is allowed to stand in the bed is spoken of as the period of contact. In percolating filters the sewage is not held up, but is allowed to percolate through the filter.'*

The filtering medium may be coke, saggers, clinker, mendip stone, etc. ; coke and saggers are apt to undergo early disintegration. The slate-beds designed by Mr. Dibdin have proved very satisfactory at Devizes.

For practical purposes the effluents from beds, under competent management, may be considered as identical in nature. The organic matter is more or less completely converted into inorganic matter, and the resulting liquid is apparently free from anything of an offensive nature ; in fact, so complete is the change that I have seen the attendant at the Barrhead Works, near Glasgow, swallow a tumblerful of the above with apparent relish. Until a comparatively recent date it was believed that the change was effected solely by means of bacteria, but we now know that there are probably other forces at work in addition to the above, as the beds swarm with a variety of animal forms, such as leeches, worms, larvæ of many kinds, and a peculiar jumping insect, known as the 'podura,' which latter is present in such quantities 'that it can be actually taken away in wheelbarrows full.'†

According to one school of experts, living forms have

* Fifth Report of the Royal Commission on Sewage Disposal, p. 47.

† 'Recent Researches on Sewage Purification,' by Sidney Barwise, M.D., B.Sc., D.P.H., Medical Officer of Health for Derbyshire (*Journal of the Royal Institute of Public Health*, May, 1909).

nothing to do with the change in question, the latter being effected by physico-chemical forces which cause the deposit on the substance of the filters of colloidal matters thrown out of solution, the ultimate oxidation and breaking-down of the colloids forming the last stage of purification.*

Whether the change is effected by vegetable forces in the shape of bacteria, by animal forms in the shape of leeches, worms, etc., or by chemico-physical forces, the salient fact remains that the liquid which leaves the filter is as dangerous as the entering sewage. We have seen that Nature's method produces three distinct effects; the artificial method only produces one of the above—viz., the conversion of complex organic into simple inorganic forms. In this connection the findings of Dr. Houston leave no justification for doubt. 'He found that the effluents from septic tanks, intermittent contact beds, continuous filtration beds, etc., contain an enormous number of bacteria, even although there is some reduction of their numbers in the effluent as compared with the crude sewage. The different kinds of bacteria and their relative abundance appear to be very much the same in the effluents as in the crude sewage. As regards undesirable bacteria, the effluents frequently contain nearly as many *B. coli*, proteus-like germs, spores of *B. enteritidis sporogenes*, and streptococci as crude sewage. The effluents, then, must be regarded as nearly, if not quite, as dangerous as the raw sewage; and Dr. Houston calls special attention to the presence of streptococci, which are apparently even more delicate and easily destructible than typhoid bacilli, so that their presence in any number in an effluent seems to indicate the possibility or probability of the enteric fever bacillus also surviving under similar conditions, and, in general, would lead to the inference that the biological processes at work were not strongly inimical, if hostile at all, to the vitality of germs of pathogenic sort.'†

* 'The Mode of Action of the Biological Filter,' by T. Carnwath, B.A., M.D., D.P.H., Assistant Medical Officer of Health, Manchester (*Public Health*, September, 1909).

† 'House Drainage, Sewerage, and Sewage Disposal in Relation to Health,' by Louis P. Parkes, M.D., D.P.H., pp. 102 and 103.

It is now a matter of common knowledge that, as stated by Dr. Parkes, 'the effluents of all artificial bacterial bed processes contain the bacterial flora of sewage in great abundance. They must therefore be considered as but little, if at all, less potentially dangerous than the discharges of crude sewage. . . . Bacterial beds being what they are, it is perfectly impossible that they can ever retain in their substance, or otherwise eliminate, the bacterial organisms in sewage.'*

The question of what constitutes a good effluent naturally occupied a prominent place in the work of the Royal Commission. The opinions of sixteen experts were obtained, and in only one case did the answer—viz., that of Mr. Fowler of Manchester—include absence of pathogenic germs as an essential factor; it may therefore be inferred that the absence of such germs is not to be expected.†

The question of sterilizing the effluents by artificial means was also considered, but the prospects of doing so were not very encouraging. Dr. Barwise drew attention to the method adopted at Trouville, in which heat was employed, the liquid being driven off as steam and the solids remaining sold as manure, but he added that such a system was 'quite impracticable in this country.'‡

In connection with the loss of manurial material, the Commission found that 'It is in the form of nitrate that nitrogen is taken up by most plants. Much has been written about the loss to the country arising from the non-utilization of the nitrogen of sewage which has been purified by artificial filtration, a loss which is certainly to be deplored. . . . There is, unfortunately, no economical method of extracting the nitrate from a sewage effluent otherwise than through the agency of plants, and, as we have stated, there must be a considerable loss of valuable nitrogenous manure

* 'House Drainage, Sewerage, and Sewage Disposal in Relation to Health,' by Louis P. Parkes, M.D., D.P.H., pp. 130 and 131.

† Fifth Report of the Royal Commission on Sewage Disposal, Appendix II., p. 207.

‡ *Ibid.*, p. 8.

from water-borne sewage even in the case of land purification; supposing the effluent to be subsequently discharged into a stream, the loss is, of course, much greater, all the manurial constituents of the sewage, apart from those in the sludge, being wasted.' *

A lamentable fact in connection with this waste is that, as the nitrogen exists as nitrates, it is in the readiest form for plant assimilation. If we assume that the excreta of each individual in the United Kingdom is worth two shillings and sixpence per annum—a low estimate—we can form an approximate idea of the sums annually subtracted, in the form of sewage, from national defence or other useful purpose.

On the whole we may safely come to the conclusion that the systems commonly employed for sewage disposal are productive of wholesale waste, and fail utterly in effecting purification in the sense naturally understood by a confiding public.

The necessary means of obtaining safety and avoiding waste are sufficiently plain, and in connection with the former, the words of Mr. H. A. Roechling are of unmistakable meaning. Concerning the question of sterilizing sewage by artificial means, he states as follows: 'I would point out that for all practical purposes the passing of sewage through suitable land on a well-managed sewage farm has sufficed up to now to deprive it of its pathogenic micro-organisms, and in proof of this I would mention that there is no case on record, so far as I know, where the effluent from a well-managed sewage farm has caused an outbreak of typhoid fever. The method is not an absolute guarantee for such removal, just as little as an artificial process of sterilization would be an absolute guarantee; both methods are subject to a number of errors, depending partly on human agencies, which will never be completely effaced; but so far the method of land treat-

* Fifth Report of the Royal Commission on Sewage Disposal, pp. 150 and 151.

ment affords the only practicable, reasonable, and well-tried method for such removal.' *

The subject of danger arising from sewage farms has been fully investigated, and the knowledge obtained does not justify reasonable apprehension, Mr. Roechling's views being fully supported by the results of actual experience. The conclusions arrived at by Dr. Houston are directly corroborative of the above.

'On the other hand, Dr. Houston found that with land of proper quality, and by intelligent management, it was possible to obtain effluents of remarkably good bacteriological character—in some cases so good that, apart from a knowledge of its source, the effluent might actually be regarded as a potable water of more than average quality.' †

A particularly interesting object-lesson in the present connection is found in the Plain of Gennevilliers, near Paris.

The following extract from the official report of this admirable institution gives an excellent idea of the nature and extent of the work done: ‡

'Le volume d'eau d'égout envoyé dans la plaine de Gennevilliers, qui n'était que de 1,765,621 mètres cubes en 1872, a atteint en 1898, comme on l'a vu plus haut, le chiffre annuel de 38,148,302 mètres cubes. Les machines de Clichy ont fourni 13,812,515$^{m^3}$, et la dérivation de Saint-Ouen 24,335,787$^{m^3}$.

'Le volume annuel des eaux épurées déversées en Seine par les drains a été en 1898 de 7,377,380 mètres cubes.

'*Composition des Eaux d'Égout.* — La composition des eaux d'égout est la suivante d'après les analyses chimiques et micrographiques du laboratoire de Monsouris :

Degré Hydrotimétrique.	Matière Organique.	Azote. Nitrique.	Azote. Ammoniacal.	Bactéries.
40	4,39	2,1	20,6	12,162,500

* Fifth Report of the Royal Commission on Sewage Disposal, p. 31.

† 'House Drainage, Sewage, and Sewage Disposal in Relation to Health,' by Louis C. Parkes, M.O., D.P.H., p. 103.

‡ For information in this direction I am indebted to the courtesy of the Director of Sewage Disposal at Gennevilliers.

'*Eaux de Drainage.*—La nappe souterraine reste à un niveau peu élevé par suite de l'établissement des drains. La pureté des eaux de cette nappe, frappante au seul coup d'œil à la sortie des drains en Seine, a été vérifiée par de nombreuses analyses :

Degré Hydrotimétrique.	Matière Organique.	Azote. Nitrique.	Azote. Ammoniacal.	Bactéries.
58	1,2	28,4	0	3,000

' Le poisson y vit parfaitement ainsi qu'on peut le constater dans la petite rivière du jardin de la ville, à Asnières, où coulent les eaux du drain des Gréssillons avant de déboucher en Seine.

'*Surface Irriguée.*—La surface irriguée a subi une progression croissante ; partie de 50 hectares en 1872, elle atteignait 295 hectares en 1876 ; 450 en 1880 ; 616 en 1884 ; 715 en 1889 ; elle est actuellement de 900 hectares.

' La meilleure preuve que l'entreprise d'assainissement de la Ville de Paris a réussi au point de vue agricole est fournie par le régime même de l'irrigation. L'usage de l'eau est absolument libre ; aucun cultivateur n'est obligé d'en prendre ; chacun peut en consommer autant qu'il lui convient. La ville n'a pas de terre à Gennevilliers, elle n'a que des clients ; elle n'en trouverait pas si la culture à l'eau d'égout réussissait mal ou n'était pas lucrative. Mais elle réussit et on y gagne de l'argent. Les cultivateurs bien avisés prennent l'eau ; la progression de la surface irriguée en fait foi.

' *Valeur des Terrains.*—La valeur locative des terrains qui était anciennement de 100 à 150 francs l'hectare est aujourd'hui de 500 francs dans tout le périmètre irrigué. Quant à la valeur du fonds, elle est de 10 à 12,000 francs l'hectare ; elle atteint dans quelques transactions 20 à 22,000 francs l'hectare.

' *Rendement des Cultures.*—Les rendements des diverses cultures sont des plus élevés :

Artichauts...	50 à 80,000 têtes à l'hectare.
Choux-fleurs et choux ordinaires ...	20,000 „ „
Pommes-de-terre	15,000 kilg. „
Poireaux	7,500 bottes „
Épinards	15,000 kilg. „
Asperges	2,000 bottes „

'Le produit brut obtenu à l'hectare est des 4,000 francs environ. Le produit net, déduction des frais loyer, de labour, de semis, etc., estimés à 1,200 ou 1,500 francs l'hectare, ressort donc en moyenne à 2,500 francs l'hectare. . . . L'état sanitaire ne laisse rien à désirer. Depuis plusieurs années il serait impossible de citer l'ombre d'une plainte à ce sujet.'

The diminution in the number of bacteria is most interesting, as corroborative evidence relative of the rapid destruction, under suitable conditions, of intestinal germs in the soil. The advantage as contrasted with filter-beds scarcely needs to be pointed out. It is, in short, the principal of utility and safety which Nature provides, and which man neglects.

In view of their direct bearing on the economics of Indian sanitation, the above facts have been discussed at some length, and they may prove of interest not only to medical officers, but to all officers serving in the Eastern Empire. In India the application of organic refuse to the soil may well be said to be universal.

Whether the measure is successful in the best sense of the word, or whether it is simply an intolerable nuisance and a source of danger and disease, depends on a variety of factors which can scarcely be studied in detail here, but the general principles of which ought to be familiar to all those whose duties are in any way related to the health of troops.

The general means adopted in India is one of shallow-trenching, commonly known as the Allahabad system. At stations where the natural conditions are suitable, and where the method is carried out under intelligent and responsible supervision, the results are excellent. Some of the main points to be considered are as follows :

1. The nature of the soil.

2. The depth at which the refuse should be buried.

3. The quantity of refuse to be applied at any given locality.

4. The presence or absence of vegetation.

A loose loamy soil is one of the best possible, and a sandy

rock soil is one of the worst. Clay and peaty soils are also generally unsuitable. Point 1 will, in the main, govern points 2 and 3. It is impossible to lay down precise rules that will meet all cases. It is evident that a suitable soil can have its powers, and in the way of bacterial agencies, taxed to an extent that would be unjustifiable in the case of one less well adapted to the purpose in question. Experience, coupled with careful observation, will assist in arriving at a satisfactory conclusion. The fourth point named above is of fundamental importance. The vegetable world, as already explained, finds its nutriment in the final products resulting from the conversion, by soil organisms, of organic into inorganic matter; as a ferment ceases to act in an excess of its own products, so we may assume that, unless plant-life is present to remove, as nutriment, the completed work of the soil bacteria, the latter are unable to continue their functions, and the production of a partially altered and fœtid residue is the result. In short, if the bacteria are overworked, or the product of their labour is not removed, failure of the system must ensue; and as growing vegetation is a proof of the presence of the necessary vital agencies and of the means for the removal of their completed work, the guiding principle to success should be easily apparent.

At those stations in India where what are locally known as 'filth-pits' are under military control, the shallow-trench system, as far as my experience allows me to form an opinion, works well. The trenches are constantly inspected, and great care is taken that natural agencies are not overtaxed, and that the growth of vegetation is encouraged. Judging, however, from published reports, matters in cantonments are not always so satisfactory.

In view of its great importance, this system calls for attention in some detail. The principles upon which it is based are those which were elucidated by Warington in his experiments at Rothamsted. These principles comprise, in a general sense, the conversion of organic into inorganic matter, which has already been discussed, together with the best means for utilizing this change for the purpose of practical farming.

The method of application in India, which owes its inception to Major A. C. Williams, Chief Supply and Transport Officer, Meerut, and to Major D. J. Meagher, late Director of Grass Farms, is thus described in the words of these officers:

'SHALLOW SYSTEM.

'The shallow-trench system, which is described below, is now sanctioned by regulation. Wherever the method is practised correctly it is sure to give every satisfaction, and where it is not working satisfactorily it is certain that the system has not been followed. As a substantial proof of the correctness of the system, a horse galloped over ground recently operated on should not make an impression in the soil deeper than 2 inches. It is a misnomer to term this the "shallow-trench" system; a more appropriate term would be the "surface disposal of night-soil.'"*

'In several cantonments where objection was made to the system after experiments, it was observed that, owing to some misunderstanding, a modified form of deep trenching had been tried, and not the Allahabad shallow system. This was at once perceptible from the fact of horses sinking almost knee-deep into the soil when taken over it.

'*Method of Disposal.*—The superficial area of each space required for the contents of a Crowley pattern filth-cart, containing 60 gallons, has been found to be 80 square feet. The area required per cart of other dimensions can be readily calculated on this basis. The most suitable dimensions for this 80 square feet are 16 feet long and 5 feet broad. Three inches of the top surface of this space are removed and placed on the embankment of the plot nearest to which the first line of trenches is dug. The land is, of course, first *gathabanded*, and the trenching begun close to the embankment. The subsoil thus exposed is well pulverized to a depth of at least 9 inches. When the contents of the cart are tipped into the centre of the trench, the liquid matter rapidly soaks into the loosened soil, while the solid excreta remain on the top. This solid matter is less than $\frac{1}{8}$ inch thick. Three inches of earth are then removed similarly

* For illustration of The Allahabad Trench, see Fig. 40, p. 381.

from the top of the next trench, which is dug parallel to the first, with no intervening space. The soil dug from the second trench is thrown over the night-soil in the first trench, and the process repeated. The above generally applies to cantonment filth-carts, which contain a large quantity of urine and cook-house water, the night-soil comprising only about one-third of the contents.

'The municipal filth-carts employed in bazaars and cities, on the other hand, largely contain solids, as, owing to defective sanitary arrangements, the liquid is not collected. In this system, therefore, there is no necessity to pulverize the bottom of the trench.

'*Supervision Simplified.*—It has frequently been argued as an objection to the surface form of disposal that it is difficult to supervise. Those who thoroughly understand the method are agreed that it can be more effectively supervised than any other system. All that the overseer or supervisor has to do is to see overnight that sufficient spaces, according to the daily number of filth-carts, have been prepared, and he can easily ascertain if the soil has been sufficiently pulverized by thrusting his stick into each pit. He need not return until the following evening, when he should see that the areas or spaces prepared have been properly filled and covered, and that sufficient trenches for the next day are dug. If he should neglect to do this, the sweepers will naturally empty two carts into one space to save labour in digging.

Suited to Every Season.—Experience teaches us that it is by far the best-known system for both wet and dry seasons. It has been carried out at Allahabad for fourteen years without any hitch, and on various descriptions of soil, including stiff clay, black cotton, and sand. At Allahabad the success achieved is mainly due to the farm having remunerated the cantonment sweepers and beldars engaged in the work, and unless this is done elsewhere, it will not be possible to insure the work being carried out satisfactorily and in accordance with the instructions given above.

'*Approved by Scientific Authority.*—The night-soil thus trenched decomposes in less than a week, and even after

three days all effluvium disappears. Before the system was pronounced safe on sanitary grounds many successful experiments were made by Surgeon-Colonel Martin, who was Principal Medical Officer of the Allahabad District at that time. The trenching-grounds have been inspected by most of the medical, sanitary, and other scientific authorities in India, including the Principal Medical Officer of His Majesty's Forces, all of whom have expressed their unqualified approval of the system.

'*Juar or Millet to be Sown with Dub.*—Crops can be successfully grown immediately after trenching, and even in the cultivation of grass the first crop is greedily eaten by cattle. Such land should be put down to grass without ploughing. As regulation demands the sowing of a sorghum crop on land trenched with night-soil, this should be done without disturbing the soil and exposing the newly-buried night-soil.

'At Allahabad sorghum and grass are sown together, as described below. Juar is first sown broadcast, with about 7 pounds of seed to the acre. The chopped dub is then sprinkled over the seed, and the whole lightly covered with earth.

'*When the Crop should be Cut.*—It will be found that these two will grow together, and when the juar has attained the height of about 4 feet, and the grass the height of about 1 foot, the whole should be cut together and issued to horses, mules, bullocks, pigs, or milch cattle.

'If allowed to grow higher, the grass will suffer, owing to the excessive heat and want of ventilation caused by the juar. Both crops will shortly reappear, and should be again cut at the same height. The third crop will contain very little juar. About six cuttings are obtained during the year, with a total out-turn of from 600 to 800 maunds. Land thus trenched with cantonment night-soil will require re-manuring after about five years, while land similarly treated with city night-soil will last fully seven years. If necessary, and especially where the space available for trenching is limited, the ground can be treated every second or third year.

'*Advantages.*—The system of surface disposal enables about

seven times as large an area of land to be manured as could be done under the deep-trench system with the same quantity of manure. Such land rents readily at from 20 to 45 rupees per acre, and this means that it is possible to raise the revenue of cantonments under this heading very considerably.

'*Rapid Decomposition.*—Rapid decomposition in the shallow-trench system is due to the excreta being exposed (with a protection of only 3 inches of earth) to the action of the sun and atmosphere. Considerably less than 3 inches of earth would suffice to keep down the smell, but as such trenching is usually carried out on very poor or barren land, with little or no depth of soil, it is beneficial to the land to have 3 inches over the manure, thus adding to the depth of the soil.

'The cost of this system of manuring cannot be fully calculated, as the cantonment night-soil is usually obtainable free. The only expenditure to be incurred would be as follows:

Extra remuneration to cantonment conservancy establishment, including overseer, per acre ...	Rs. 30	0	0
Seed per acre	0	6	0
Labour for sowing and covering	12	0	0
Total	Rs. 42	6	0

'After many trials and experiments of the various methods of disposing of night-soil from a sanitary point of view, the method here described has been found to answer best, while at the same time, from an agricultural point of view, it is far superior to the old methods of deep trenching.' *

Several objections have been raised against this mode of manuring:

1. That it spreads enteric fever by the disposal of infected dust or by the washing of the dejecta into watercourses during the rains.

2. That it is a fertile means for the propagation of flies.

3. That night-soil is uncovered by birds.

4. That the odour from the trenches is great enough to be a nuisance.

* 'The Farm Manual,' pp. 21-23.

5. That during the hot weather the fermentation of the excretal matter by evolution of gas displaces the thin layer of covering earth.

6. That during the monsoon the system breaks down owing to flooding of the trenches.

These objections may be considered seriatim.

'1. The system of shallow trenching began to be carried out in 1895, except in the case of Allahabad, where it began earlier; but it is fair to assume, in the absence of official information, that it was not generally adopted for some two, or possibly three, years later. In the above year the admission-rate for enteric was 22·6 per 1,000, and in the succeeding years, up to 1908, which is the last year in connection with which the records of sickness have been made public, the rates are as follows :

1896 ...	... 25·5 per 1,000	1903 ...	... 19·6 per 1,000
1897 ...	... 31·8 ,,	1904 ...	... 19·7 ,,
1898 ...	... 36·3 ,,	1905 ...	... 16·1 ,,
1899 ...	... 20·6 ,,	1906 ...	... 15·6 ,,
1900 ...	... 16·0 ,,	1907 ...	... 13·1 ,,
1901 ...	... 12·8 ,,	1908 ...	... 14·6 ,,
1902 ...	... 16·7 ,,		

It will thus be seen that there has of late years been a remarkable decrease in the admission-rate up to 1907 inclusive, and that the beginning of this decrease coincides approximately with the year in which the shallow-trench system had probably spread itself through the country. Reference to the published reports of the Army Medical Service show that this decrease is not by any means due alone to a diminution in the number of men at the susceptible age, but that the increase in 1902 and 1903 is apparently due to an increase of the number of young soldiers rather than to insanitary conditions.*

'At Lucknow a steady decrease in the number of cases of enteric fever has been observed ever since the Government dairy began issuing milk and butter in the latter part of 1898. . . . This dairy, which used to supply milk to the men of the 20th Hussars, has now been put out of bounds,

* Army Medical Report for 1902, p. 201.

and milk and butter can be procured from an excellent Government dairy under the supervision of a trained European.'*

It should be observed that the Government dairy is carried on in connection with a Government farm, where the shallow-trench system is in force. The shallow-trench system thus assists in maintaining an institution which has been officially stated to be a distinct factor in the decrease of enteric fever.

Since 1902 the admission-rate for Lucknow per 1,000 of strength has been as follows:

1902	28·5	1906	36·0
1903	37·7	1907	12·2
1904	51·6	1908	14·3
1905	27·8		

It is true that the admission-rate in certain of the years referred to was not at all satisfactory, but this fact, in view of the subsequent fall, cannot reasonably be attributed to the shallow-trench system. In 1902 the high ratio was attributed to contamination of the municipal water-supply.

Whatever evil effect the shallow-trench system has on health, statistical evidence certainly does not lend support to any theory of a general increase of enteric fever throughout the country from this cause; although, on the other hand, it would be idle to assert that complete freedom from danger obtains in this direction. The manner in which infection may spread is considered under the next heading.

2. This objection I believe to be valid.

The presence of flies can no doubt be partly accounted for by the filth-carts, and partly by the animals on the farm. Mango-trees in blossom are also fertile sources of attraction, and if these trees are near the trenches, a false conclusion may be arrived at concerning the cause of the number of flies present. But, apart from the above, there are other factors at work directly connected with the system itself.

* Army Medical Report for 1901, p. 159.

The following is a brief account of my own observations in this direction :

Fly larvæ are present in countless numbers in refuse which has been buried three days, and on the fourth day pupæ and larvæ are to be found in approximately equal numbers. The larvæ now tend to disappear, until by the twelfth day comparatively few are left, their conversion into pupæ having largely taken place. It is an easy matter to extract a practically developed fly from its pupal covering any time after the sixth day. By the twelfth day the empty cases are common, and after the twelfth day they appear to be the rule rather than the exception. These statements are not in the least intended to be a comprehensive account of what occurs, as officers who have great experience of the system in question inform me that the rapidity of the changes varies according to the season of the year, and there are probably a variety of other influences at work which it would be difficult, if not impossible, to completely work out. I know from observations in the laboratory that the process is considerably lengthened in cold weather.*

The question which naturally suggests itself is, What becomes of the flies ? Captain Ellis, in charge of the Grass Farms, Meerut (to whose courtesy I am greatly indebted for much valuable information), told me that in the winter of 1903-1904 he had 'crushed some hundreds of the chrysalides, and never found a full one ; they were all empty shells.'

After careful search I have only found one dead fly beneath the surface. It is clear that the flies hatch out, and it is equally clear that they do not perish underground, as some have suggested, but that they reach the surface. About this there is no doubt whatever.

With the object of ascertaining the fate of flies, earth and night-soil from the trenches were placed in a glass box, and conveyed to the laboratory at Meerut on December 1, 1904.

* In connection with the breeding of flies, there is an interesting article by Major A. R. Aldridge, R.A.M.C., in the *Journal of the R.A.M.C.* for December, 1904, 'Spread of Infection of Enteric Fever by Flies.'

The top of the box was next covered with muslin, and the edges of the muslin carefully fastened down with gummed paper, so that it was quite impossible for flies to effect either egress or ingress. The night-soil and earth were carefully arranged in the box by the European overseer on the farm, so as to form an exact imitation of a shallow trench. The box was kept in the sun. On December 4 a fly made its appearance; it was in a sickly condition, and promptly died. On the 5th another fly appeared; this one survived. On the afternoon of the 6th several flies appeared, and by the morning of the 7th the space between the earth and muslin cover was swarming with them.

The general course of events appears to be as follows: The ova are deposited in the latrines, and are conveyed in the filth-carts to the trenches; the larvæ and pupal stages take place beneath the ground, and the developed fly makes its way to the general atmosphere through the covering of earth.

Further evidence as to the rôle played by flies is found in the following extract from the Army Medical Report for the year 1907, p. 101:

'It is now well recognized that house-flies are bred in enormous numbers in the trenches in which night-soil is deposited in India, the numbers at certain seasons in many stations being so great as to make it probable that a large proportion of the flies found about barracks come from this source. Now, a study of the incidence of enteric fever shows that stations where there are no filth trenches, or where they are a considerable distance from barracks, are, without exception, among those having a very low admission-rate. This is shown in the table on page 356, in which stations having no night-soil trenches, or only at a considerable distance, are marked with an asterisk; in all the remainder it is trenched seldom more than a mile away.'

The possibility of the spread of enteric fever by such means is too evident to need discussion, but it would be unsafe to arrive at an absolute conclusion until all determining factors were definitely known.

3. There are generally a fair number of birds to be seen on the covered trenches, but they are not usually of the carrion kind, such as crows or vultures, although both the latter are attracted by the presence of any dead animal in the filth-carts.

I have never seen any kind of bird on recently covered trenches; as a rule, there are no birds on trenches which have been covered less than six days. I have uncovered the

TABLE SHOWING THE MEAN ANNUAL AVERAGE ADMISSION-RATE PER 1,000 FOR ENTERIC FEVER FOR BRITISH TROOPS AT ALL STATIONS WITH A STRENGTH OF 500 OR OVER, 1903 TO 1907.

*Colaba	1·8	Ferozepore ...	15·5
*Calcutta	3·2	Bellary	15·6
*Lebong	3·5	Quetta	18·0
*Rangoon	4·0	Sialkot	18·0
*Karachi	4·8	Ranikhet	18·4
*Aden	5·0	Lahore Cantonment	18·8
Multan	5·8	Kirkee	18·9
Allahabad	6·4	Rawal Pindi ...	20·8
*Madras	7·0	Amballa	21·5
Nowshera	7·7	Secunderabad ...	22·0
*Dagshai	7·9	Bangalore	23·4
Thayetno	8·7	Peshawar	23·4
*Chakrata	9·3	Agra	24·5
Wellington ...	9·6	Jubbulpore ...	27·5
Bareilly	9·7	Dinapore	28·5
Ahmednagar ...	11·3	Poona	29·9
Belgaum	11·9	Mhow	32·6
Cawnpore	12·8	Lucknow	33·1
Fyzabad	12·8	Nasirabad	34·9
Jullundur	13·3	Meerut	37·4
Dalhousie	13·5	Jhansi	41·6
Kamptee	14·8		

night-soil, in places, when many birds were feeding about the trench area, but I never saw any of the birds attempt to take advantage of this opportunity.

4. I have never detected an odour which could reasonably be called a nuisance from the trenches; in fact, there is scarcely any odour to be detected at all, even over the newest trenches.

The filth-carts may be a nuisance, but I have rarely found

them so when under cantonment control; when under other administration, matters are very different. When the lids fit properly there should not be any nuisance, but it is a good plan to direct the drivers to cover the lids with dry earth or grass; of course, filth-carts have to be used whether deep or superficial burial is in vogue. Even under the best administration the filth-cart is a singularly disgusting and insanitary institution.

FIG. 35.—CROWLEY REFUSE-DISPOSAL CARTS.

5. I have no personal knowledge of this defect, but I am informed on good authority that it certainly exists; it appears, however, to be an easy matter to cover the local extrusions. It is stated that the latter are only found during the hot weather before the rains.

6. The heavy rains in the monsoon season doubtless militate against the system, but any serious results are obviated by digging the trenches slightly deeper.

If, in the light of further information, no valid reason is

forthcoming why the system should not be carried on at a greater depth, objections 5 and 6 would disappear.

The fate of intestinal germs in the soil is an interesting question, and one of an exceptionally practical nature. The night-soil is indistinguishable, as such, within a week, and the earth of the trenches is devoid of any offensive characteristics perceptible to the unaided senses. This change, as we know, is effected by bacterial forms, and it remains to be seen how far these forms can exist in common with those found in the excreta. I undertook certain experiments in the laboratory at Meerut, with the object of gaining some information on this point. The method, in general terms, consisted in the inoculation of various nutrient media with earth taken from a depth of about 4 inches, at varying times after burial of the night-soil. I never succeeded in obtaining colon-like forms later than the fifth day, but I should be sorry to arrive at any definite conclusion as to the viability, in this connection, of the colon family until my observations have been confirmed by others, after experiments conducted under many conditions of soil, temperature, locality, etc. Flies, also, were caught with sterilized forceps, during a previous experiment recorded in this chapter, and were then introduced, alive in some cases, into different media. Here, again, I failed to detect intestinal forms. The experiments, as in the case just recorded, were not in the least conclusive, and have only been mentioned as suggesting a useful and interesting field for future inquiry. It should be remembered that *B. coli* is stated to be a normal inhabitant of the intestine of the fly.

The financial aspect of this mode of refuse disposal may, in its connection with health, be briefly mentioned here. As seen by the preceding extract from the 'Farm Manual,' the financial advantages are, without entering on details, obvious; and these advantages have allowed an extension of the farming system which promises to insure to the army in India food-supplies concerning the general excellence of which no reasonable doubt should arise, and which should be a potent factor in diminishing the sickness-rate among troops.

Distinct frcm all other considerations, the economic value to the State of a decline in sickness is sufficiently clear.

Without receding in any way from preceding statements, I must admit that there are doubtless many stations where the shallow-trench system is inapplicable; among these stations appears to be Quetta, and an article in the *Journal of the R.A.M.C.* for November, 1904, by Lieutenant-Colonel Battersby, throws valuable light on the sanitary difficulties which obtain there, and on the manner in which they have been overcome. As evidence of the danger of shallow trenching under unsuitable conditions, it is a striking fact that the above station, where this system cannot be satisfactorily carried out, has had in late years a most unenviable notoriety for the prevalence of enteric fever. The soil is rocky and arid, and therefore does not lend itself to the vital danger necessary for purification.

I should also explain that the shallow trenching that I have seen has been in most able hands, and I am quite prepared to believe that negligence or incompetence would have serious results ; but, on the other hand, the abuse of a system of any kind does not justify the condemnation of the system itself. Statistical evidence already set forth tends to show, if a satisfactory standard of health is an indication of care and skill, that the opposing attributes, as affecting this matter, must be rarely found. The great objection to the system is found in the propagation of flies, and this is quite sufficient to render the application of the system inadvisable in the neighbourhood of dwellings. The officer commanding a native regiment at Meerut told me that his men never went on the ranges, which were near the trenches, without coming back covered with flies. I have also known the inhabitants of bungalows situated in the same neighbourhood complain bitterly of the fly nuisance.

I should make it absolutely clear that the preceding statements are only intended to apply to refuse disposal when carried out under military supervision. Such experience as I have of municipal sanitation in India leads me to

entertain a rooted conviction that it offers a fruitful field for official inquiry.

I had the misfortune to be for a short time in a station where these arrangements were entirely in the hands of the municipal authorities, and where, consequently, the native labourer was in great measure allowed to act according to the dictates, if not exactly of his own judgment, at any rate of his own convenience. The result, to those acquainted with the lower order of native, is not difficult to imagine. What was called, in courtesy, refuse disposal consisted in the wholesale dumping of the contents of the filth-carts and of other forms of refuse—notably the offal from the slaughterhouse—on different allotted areas of waste land, and sprinkling the matter with a sparse covering of sandy soil. There did not seem to be the faintest attempt at either adapting the amount of refuse to the extent or nature of the land, or to encourage the growth of vegetation. To all practical intents, the refuse was simply left to rot away, without any adequate effort either to utilize it, or to render it innocuous. It was also a noteworthy circumstance that, as dust-storms were frequent, we must have swallowed with our food and at other times an appreciable quantity of this filth. The civil surgeon was fully aware of the possible consequences that might arise, and he made every effort to effect an improvement, but was met on every hand with a *non possumus*. On inquiring the cause of the failure to abolish what was actually a source of constant and urgent danger, I was informed that 'India is a poor country, and we have not the money to spend on sanitation that you people have at home.' Concerning the justice of this remark I am not prepared to speak, but it is remarkable that at the same time the municipality was actively engaged in an extensive scheme of electric lighting.

To call such a state of things shallow trenching is simply an abuse of words, and the slum-dweller who empties the contents of a chamber-pot through the window and on to the passage below would be equally justified in describing his action as 'the application of organic refuse to the soil.'

The system of trenching may be said to begin in the latrines. Up to within a very recent date dry earth was supposed to be employed, but this system, or, rather, want of system, has fortunately disappeared as far as British barracks and hospitals are concerned, and has been replaced by the use of a solution of saponified cresol. It may be too early to form an absolute opinion, but the change justifies a hope that the breeding of flies in uncovered excreta, and the consequent development of these insects in the filth-trenches, may to some extent be inhibited. In this connection it has been well pointed out by Major M. P. Corkery, R.A.M.C., that an inspection of the latrines in the evening may furnish startling object-lessons in sanitary neglect.*

It may here prove of interest to refer briefly to the past, and the following is so truthful and so vivid a description of a defunct system of sanitation that it would be difficult for the uninitiated to obtain a better idea of certain of the conditions to which the British Army was formerly exposed:

'In barracks the latrines have mud floors for the most part, the seats are without lids, and the fæces are passed into a row of conical earthenware pots . . . which are sufficiently far from the seat to insure that the ground shall be soiled with urine, at any rate. The pots are cleared out superficially without the use of any disinfectant, and the fæces are supposed to be covered with dry earth when they are passed. A dust-strewn floor, invariably contaminated, a row of contaminated pots open to the visits of flies, and a provision of dry dust to pour on to the fæces . . . all this within a few yards of the barrack-rooms.' †

According to recently published reports, rapid improvements are in course of execution in connection with the Indian latrine system. These include impermeable floors to

* *Journal of the R.A.M.C.*, November, 1909.

† 'Our Present Position with regard to Enteric Fever in India,' by Captain W. E. Harrison, R.A.M.C. (*Journal of the R.A.M.C.*, July, 1904).

latrines, slate facings for urinals, and improved rubbish-carts. Most interesting of all is the fact that it is proposed to install a sewerage system with biological treatment and disposal of the effluent on land, in connection with a new set of barracks and a new hospital now being built. This will be the first installation of the kind in connection with Indian barracks. It is particularly to be noticed that the effluent will be applied to the land; the purifying and economic effects of shallow trenching will therefore be retained, while the offensive and dangerous characteristics of the last-named system will disappear. Unfortunately, no method of sewage disposal, no matter how perfect, will effectually protect the British Army against the ocean of unwholesome ignorance which helps to constitute the lower class of Indian life.

It is likely that the trough latrine used in the United States Army would go far to help to solve some problems of Eastern sanitation. The following is the official account of the apparatus in use: 'The dejecta are dropped into a trough of galvanized iron, the shape of which presents a curved surface throughout, so as to avoid corners in which excreta might collect, and to insure perfect emptying and cleaning. The trough is charged with a sufficiency of water in which enough quicklime has been added to make an efficient disinfecting mixture. A urinal discharges into this trough. A closet is provided for sheltering, and the whole is arranged for crating and transportation from place to place with the command. The trough, when in use, is emptied by an odourless excavating apparatus consisting of a water-tight tank, having a capacity of 500 gallons, carried on a strongly-constructed waggon-bed. The pumping cylinder is mounted on wheels and drawn at the rear of the waggons.

'This trough system is now in successful use at Camp Meade, Pa., and in camps established at the presidio of San Francisco, Cal., for the muster out of the State volunteers returning from the Philippines, and for the recruits and new regiments awaiting transportation to those islands. The details of the system are given in the following order:

'GENERAL ORDERS NO. 170.

'HEADQUARTERS OF THE
ARMY ADJUTANT-GENERAL'S OFFICE,
WASHINGTON,
'*September* 26, 1899.

'By direction of the Secretary of War, the following description of a system adopted for the disposal of excreta in military camps is published for the information of all concerned :

'1. *Description of Trough.*—Of the following dimensions : Length, 14 feet ; width at top, 22 inches ; depth at upper end, 15 inches ; depth at lower end, 18 inches, and parabolic in cross section. Material consists of sheets of galvanized iron, No. 22, well riveted, and smoothly soldered at joints and end. The front and rear sides of the trough are given additional strength by means of an iron rod $\frac{1}{4}$ inch in diameter, over which the edges are turned. The general shape of the trough is such as to present a curved surface throughout, thus avoiding corners in which material could collect, and to insure easy emptying and cleaning of the trough. This trough is supported by a framework consisting of four pieces so cut out as to accurately fit the surface of the trough. The four frames are placed one at either end of the trough, and the other two equally spaced. These frames are joined at the rear of the trough by two pieces 1 inch by 4 inches, one of these at the bottom and the other at the top of the frame, the strips running the full length of the trough. In front the trough is completely boarded in by 1-inch material. The lid consists of two sections, each 7 feet long, and each containing three and one-half openings, thus providing seven openings for the trough. This lid is made of $1\frac{1}{8}$-inches material, the several pieces of the lid being held together, front and rear, by a batten 1 inch by $1\frac{1}{4}$ inches wide. Each section of the lid is provided with four strap hinges screwed at the rear. The ends of the trough are boxed in, and give support to a board 1 inch by 12 inches, rising to a height of $23\frac{1}{2}$ inches in front above the lid of the

trough. The upper edge of this board is cut sloping 3 inches. These end boards give support to another board, 14 feet 4 inches long by 12 inches wide, which is intended to prevent men from standing upon the lid. This board should also be braced from the roof of the latrine.

'It will thus be seen that the trough is enclosed by a complete framework, which is intended to secure support while in use, and safety during transportation, should the latter become necessary. When placed in position, the height of the upper end of the trough above the floor, including lid, should be 20½ inches. The rear margin of the trough should be at least 4 inches from the studding of the rear wall of the building, so as to permit the raising of each section of the lid.

'The lid of the trough is divided into seven spaces, each 1 foot 11½ inches in breadth by 1 foot 10 inches in depth, the sides of the spaces being indicated by a vertical board 4 inches in height and bevelled at each end. Each space is provided with an opening so shaped as to prevent as much as possible the soiling of its edges by fæcal matter. The opening, 4 inches by 3 inches in front, expands to a width of 8 inches by 8 inches, this part having its edges well bevelled, and is then extended backwards to the rear of the trough, and cut away as much as possible without weakening too much the strength of the lid. In other words, both the front and the rear of the ordinary water-closet seat is largely cut away. This is intended to avoid both wetting the front of the seat with urine, and its rear edges with precipitate diarrhœal discharges.

'2. *Description of Urinal.*—This consists of a galvanized trough, fastened to the rear and end of the walls of the latrine at a height of 2 feet 6 inches from the floor. It measures 8 feet in length by 8 inches in width, and has a depth of 4 inches. Its rear side extends 18 inches upwards, so as to protect the wall of the latrine from any possible contamination with urine. It has a fall of 5 inches, and empties into the upper end of a large trough by means of a pipe 2 inches in diameter.

'When ready for use, water should be poured into the large

trough until it has at least a depth of 2 inches at the upper end. To this is then added one-sixth of a barrel of lime, and the two well mixed with a wooden paddle. Lime should also be well sprinkled in the urinal. By this means not only do the excreta immediately fall into the disinfectant solution, but the urine is also mixed with lime prior to falling in the trough. To better provide for the disinfection of the excreta, the contents of the trough should be stirred with a wooden paddle two or three times a day.

'3. *Description of Latrine.*—This consists of a frame building 8 feet by 25 feet 10 inches, inside measurements; height of the roof at rear, 6 feet 6 inches. The front wall of the building is prolonged 2 feet at either end, and is provided with a projecting hood throughout its entire length. This hood protects an opening, 20 feet in length by 12 inches in width, which is intended for the ventilation and lighting of the latrine. This opening, in warm climates, should be extended along the sides and rear of the building so as to insure a better circulation of air within the closet.

'The lengthening of the front wall allows for a protected entrance, 2 feet in width, at each end of the building for persons, and also for barrels containing the disinfectant.

'A door, 3 feet 6 inches by 2 feet 6 inches, is provided at the end of the closet opposite that of the urinal, through which the hose can be introduced for the removal of the contents of the trough. Through this door also the trough, enclosed in its frame, can be removed whenever it becomes necessary. The closet is properly floored, and should be lighted at night by a suitable reflecting lantern.

'4. *Description of Excavating Apparatus.*—This consists of: (1) A strongly-constructed waggon-bed, supporting a water-tight tank, having a capacity of 500 gallons. The wheels of this waggon should have wide tyres. A 6-inch opening at the rear end of the tank, controlled by the turning of a lever, serves for the purpose of emptying its contents. (2) A pumping apparatus, consisting of a cylinder capable of withstanding high pressure, two lengths of 3-inch rubber hose, each 20 feet in length, with two pairs of brass couplings, and

removable handle for working the pump. This pump is provided with side-bars for lifting purposes, and is supported upon a pair of strong wheels, which track with the wheels of the excavator waggon. When in use the pump is connected at each end of its cylinder with one of the ends of the 3-inch hose. One free end of the hose is now to be connected with the pipe on the top of the tank, and the free end of the other length of hose placed in the trough to be emptied. The pump is rapidly worked by two men, and the contents of the trough quickly pumped into the tank. (A gallon or more of water should be placed in the cylinder of the pump before the connections are made.)

'As soon as the trough has been emptied the end of the hose should be elevated and securely closed with one of the couplings provided for that purpose. The same steps should be followed in detaching the other length of rubber hose from the tank. In this way none of the contents of the pump or hose are spilled on the ground. The two lengths of hose should next be placed in position along the sides of the tank, the pump hitched to the rear axle of the waggon by the attachment provided, and the excavator waggon driven to the next trough to be emptied.

'In camp or on the march this pump should be drawn at the rear of the waggon. Three men should be assigned to each excavating apparatus.'*

A scheme of the above kind, if introduced into our army, might well be expected to have markedly beneficial results in India. In the first place, it would mean an end of the dry-earth system ; secondly, it would do away with some of the degrading and equally dangerous duties of the sweeper ; thirdly, it would be a distinct economy in transport by lessening the number of carts required for the removal of excreta (the filth-cart contains about 60 gallons, the excavating waggon 500 gallons) ; fourthly, it would probably obviate the wholesale breeding of flies in the filth trenches. Any system which avoids the fouling of the person with

* Annual Report of the Surgeon-General United States Army for Fiscal Year ending June 30, 1889, pp. 210-212.

excremental matter should, if otherwise suitable, be welcomed in India. As it is, the existence of the foul and degraded functionary who empties the receptacles, and that of his equally foul and degraded colleague who mans the box of the filth-cart, are an offence against decency and civilization, and a menace to public safety.

On service the method in which refuse is applied to the soil is one of the principal factors on which the maintenance of the health of the force must depend. The usual means employed in the case of excreta is to construct a trench of varying depth, and cover it in when the contents come within a foot or so of the surface.

The trench commonly dug is about 3 or 4 feet deep; the sides are nearly always abominably foul, and a good deal of the filth is transferred by the men's boots to the tents and camp, or location generally. The men are directed to use earth for covering purposes, and chloride of lime or carbolic powder is supplied with the same object. Both of these measures are to all intents and purposes utterly futile, as in the first place numbers of men never trouble themselves in the least about using the covering, and in the second place, even if the disinfectant (so called) does act as an effectual cover, it is absolutely ludicrous to imagine that it can have anything approaching a sterilizing effect. The organic material itself is usually in such quantities that the soil agencies are unable to cope with it, or else it is at a depth too great for it to be brought under the influences in question. When covered over, it is likely that liquefaction takes place in the same manner as in a septic tank, and the surrounding soil and, possibly, the neighbouring water-supply become horribly polluted. The danger to water-supplies is, of course, especially serious when the ground water has been opened up.

It is also noteworthy that, according to modern belief, the portion of liquid which percolates into the surrounding soil below the area which is usually the seat of aerobic organisms, becomes, by a *chemical* process, ultimately converted into inorganic material, notably basic nitrates, and it is stated that in these latter the enteric bacillus, not being called upon

to compete with the normal bacteria of the soil, finds a medium in which it may perpetuate itself for an indefinite period. These last statements are obviously only theoretical, but they may, in the future, have a sufficiently practical bearing to make the matter in question an attractive field for investigation.

Shallow trenches about a oot deep, or less, present many advantages over those dug to a greater depth. In the first place, they have to be constantly filled in, so that the sides have no time to get foul; and secondly, the organic matter, being directly in contact with the upper layers of the soil, becomes rapidly converted into inorganic matter, and, as such, is both inoffensive and useful. 'In the Mooi River camps, however, the system of trenching in shallow trenches, covered up immediately, was being employed with results markedly in contrast with the system of deep pits—that is to say, there was no offensive appearance or smell as in the latter system.' *

In the United States Army the latrine trenches are burned out before leaving camp: they are first filled in with leaves, stable litter, etc.; crude oil is then poured over the whole, and a light applied.

When possible, buckets should always be in use in the field. Whenever they are introduced, provided that disease in the form of enteric or dysentery, or both, has not got a firm foothold, the effect is remarkable in maintaining a satisfactory standard of health. As a result of experience, I regard the use of dry earth as an abomination—that is, when some form of liquid disinfectant can be substituted. The buckets become caked with filth; the dry earth gets blown over the camp; flies are found crawling in the latrines in countless numbers; paper intrudes its presence into localities where it is more than undesirable; and, lastly, the dry earth (so called), as often as not, is never used. A certain number of the buckets should be set aside as urinals, and should always contain some strong disinfectant. Camp urinals should be distinct from latrines, and there is no objection to their

* Army Medical Report for 1902, p. 143.

multiplication, as, with sufficient accommodation, men are less likely to foul the camp by constantly passing water in places most suited to their own convenience. The suggestion of keeping urinals and latrines distinct has much to recommend it. If both these necessary establishments are placed within the one screen, the men who wish to make water naturally prefer to do so outside, and they commonly carry their preference into effect. I have seen this often enough to be convinced of its truth. The buckets should be removed at suitable intervals, and the contents disposed of outside the camp. Whether the disposal shall consist of deep burial, shallow burial, or, possibly, of cremation, will have to depend on circumstances. Buckets were installed at Tyger Kloof, a camp already referred to, in the spring of 1902. The camp was, owing to this arrangement, coupled with the removal of other forms of refuse, an admirable object-lesson in field sanitation. The contrast with neighbouring camps was remarkable, and we remained almost, if not entirely, free from sickness which was working havoc elsewhere.

When buckets are not available, kerosene tins may be tried. If two holes are bored directly opposite to each other, near the top of the tin, and the ends of a bent iron rod are inserted, a very fair bucket, with handle, is ready for use.

For general use in camp, and when suitable land is not available, the McCall incinerator should be an effectual means of helping to maintain health. It has been adopted in the American Army with a great measure of success, and has received the approval of Major Munson and other officers of great experience (see Figs. 38 and 39).

The preceding principles admit of wide application alike to the conditions of home or foreign service, peace or war.

In many barracks at home, and at some stations abroad, latrine accommodation now consists of pedestal closets of the wash-down pattern, and provided with ordinary siphon and ball-cock cisterns. The system is a well-known one, and fully described in all standard works on hygiene; but

there are one or two points which need attention here. The cistern of each closet should contain at least 2 gallons of water, and this quantity should be emptied in not less than

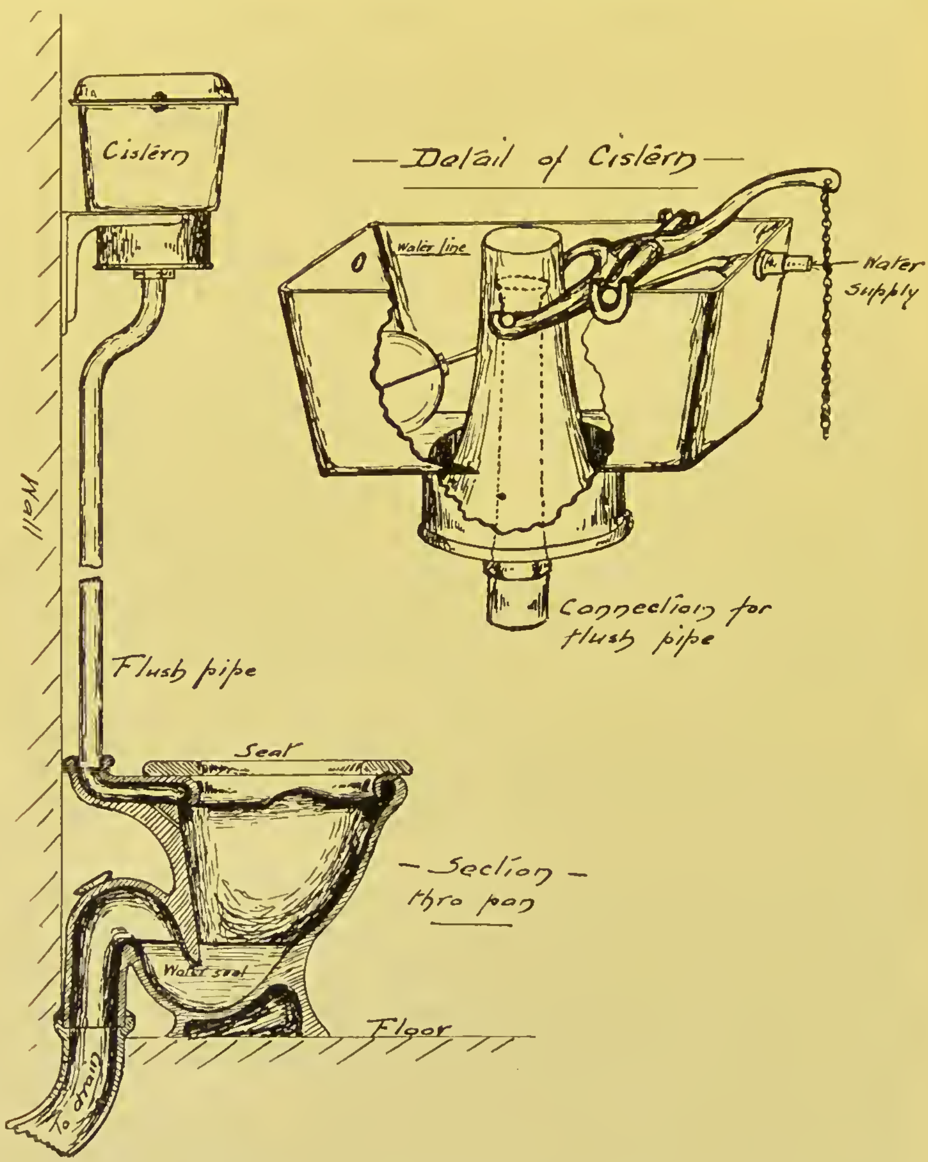


FIG. 36.—WATER-CLOSET APPARATUS COMMONLY USED IN BARRACKS.
From sketch by Quartermaster-Sergeant Revill, R.E.

five seconds; if the basin of the closet is to be cleaned out effectually, a rapid flush is necessary. It is a good plan to pull some of the chains, and note the time necessary for flushing.

If the ball-cocks are set too low, the flush is inadequate. The above defect is often present, but is easily rectified.

'A pull and let go' arrangement is necessary, as men may not take the trouble to hold the chain taut for a sufficient length of time. The water-seal should not be more than 2 inches, and the basin should hold about 4 pints. In some barracks a levelling tank feeds the cisterns of the separate closets; this arrangement means that there is only one ball-cock—viz., that in the levelling tank—and if this one ball-cock happens to be out of order the whole row of closets is affected. The trough form of latrine is disappearing, and is

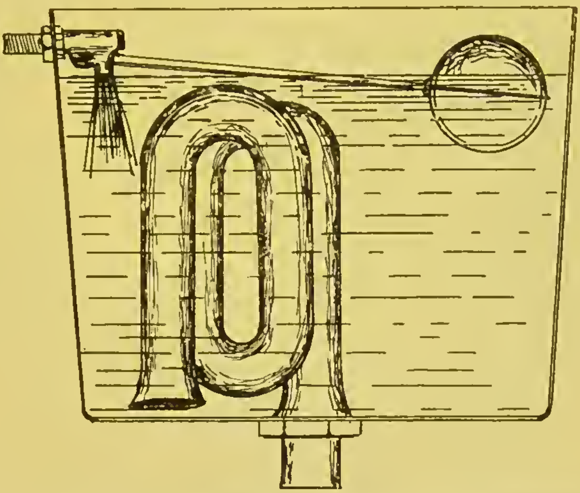


FIG. 37.—AUTOMATIC FLUSHING CISTERN WITH REVERSIBLE BALL-VALVE.

From sketch by Quartermaster-Sergeant Revill, R.E.

gradually being replaced by the above system. The troughs are commonly placed in charge of a man, usually an old soldier, who lets the water run off as required; they are a frequent source of complaint, as the attendant is not selected on the grounds of personal merit, and, unless watched, neglects the little he has to do. If provided with a siphon flush-tank, the element of human failure, in the shape of an alcoholic old soldier, would be eliminated, the amount of water used would be actually known, and it would be impossible for the system to be thrown out of gear.

Urinals can be kept free from offensive smells by the use

of heavy oil, or by a mixture of paraffin and soot, in the proportion of 1 to 3.

Satisfactory drains are found in glazed stoneware pipes, with cemented water-tight joints, or else cast-iron pipes, lined

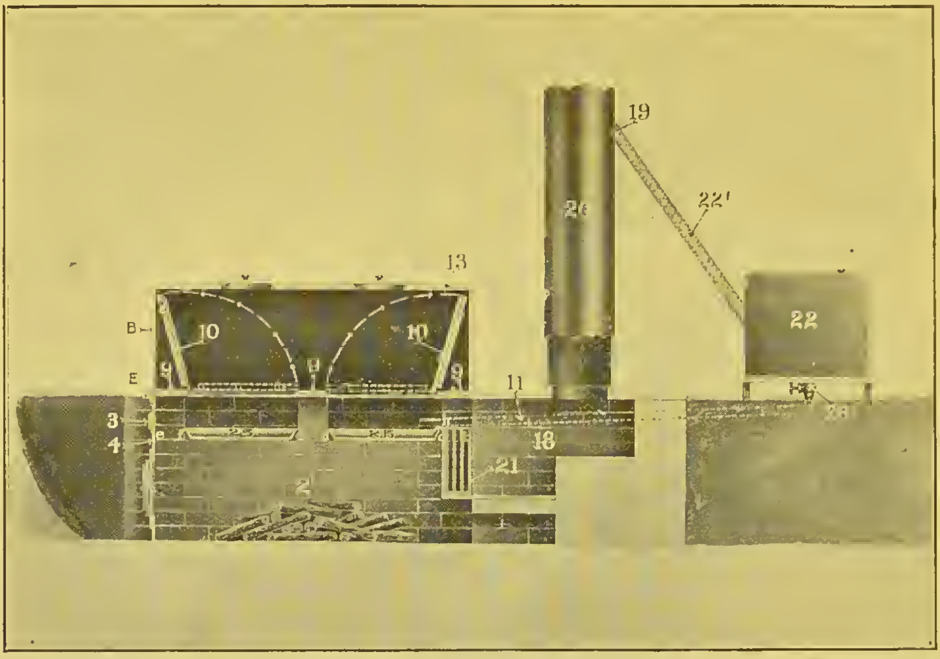


FIG. 38.—McCALL INCINERATOR: LONGITUDINAL SECTIONAL ELEVATION.

25 Iron pans for reception of excreta.
21 Grate.
22 Urinal.
22' Ventilating pipe of urinal.
11 Pipe leading from urinal to pans.
2 Combustion chamber.
10 Iron lids of combustion chamber.
18 Second combustion chamber.
20 Smoke-stack.
3 Furnace inspection doors.
9 Narrow iron plates.
26 Valve.
13 Wooden latrine seat.

The excreta fall on to the iron pans (25), and when the latter are full, the wooden latrine seat (13) is removed and the iron lids (10) are lowered. Fires are then lighted in the combustion chambers, the fire in 18 being lighted first and thoroughly ignited before a light is applied to the fuel in 2. Noxious gases emanating from 2 are thus destroyed in 18. One incinerator has eight seats, and will accommodate about 150 men. The incinerator will destroy camp garbage, both solid and liquid.

with Angus Smith's solution, with caulked molten-lead joints. A bed of concrete is necessary to insure a good foundation.

Cradles are sometimes placed at the head of the drains, so as to prevent the entrance of objects likely to cause blockage. I have some experience of this arrangement, and I can say with absolute conviction that the dangerous and

FIG. 39.—McCALL INCINERATORS AT WORK IN THE CAMP OF THE 1ST AND 3RD INFANTRY, TENNESSEE NATIONAL GUARD, JULY, 1908.

disgusting task of clearing away the collection of filth that accumulates far more than counterbalances the chance of a bottle, or other undesirable object, being thrown into the latrines. If the object of drainage is the rapid removal of excreta, then the installation of these insanitary abominations is a direct bar to success.

The question has often been raised as to whether sewer air is a vehicle for the conveyance of pathogenic germs. A series of carefully-conducted and interesting experiments by Major Horrocks, R.A.M.C., at Gibraltar, point to a positive conclusion. In the Local Government Board Reports for 1906-1907 and 1907-1908 a full account is found of subsequent experiments carried out on behalf of the Board by Dr. W. F. Andrewes. These experiments prove beyond any doubt that 'sewage bacteria are demonstrable in sewer and drain air,' 'that the streptococci in sewer air correspond in their character with those of sewage rather than with those present in fresh air,' and 'that the bacilli of the colon group, almost absent from fresh air, could be demonstrated in drain air with no great difficulty.' *

Dr. Andrewes, in concluding his able and interesting report, states that the experiments 'do not, however, touch a very important matter—namely, the degree to which air-currents may convey bacteria dissociated from sewage—a problem underlying the whole question of drain and sewer ventilation, as well as that of the escape of drain air into inhabited houses.'

The Medical Officer of the Local Government Board (Dr. Newsholme) sums up the results of Dr. Andrewes' experiments as follows:

'The importance of the facts recorded by Dr. Andrewes rests in the demonstration that sewage bacteria *may* be present in the air of a drainage system in ordinary use, and, as a matter of fact, are present after splashing has occurred. This consideration, however, is much modified by the

* 'Bacteria in Sewer Air,' by W. F. Andrewes, M.D., Report of Medical Officer Local Government Board, 1907-1908, Appendix B., No. I.

observation that the effect of a single act of splashing is transient, lasting only a few minutes. Further experiments are needed to determine the extent to which air-currents can waft the disengaged sewage droplets, and as to the possibility of detecting sewage microbes in the air of houses with defective drains, before it is permissible to conclude that infective diseases can be air-borne in this manner.'

The above experiments were in turn followed by a prolonged and elaborate series conducted by Professor Sheridan Delépine at Manchester. These experiments tend to remove any apprehension in regard to dangers arising from well-constructed sewers.

Lastly, I would venture to refer briefly to some experiments made by myself at Plymouth, which went to show that, although sewage bacteria could be demonstrated in sewer air, yet the chance of their escape, with resulting public danger, was not to be seriously apprehended.

As sewers are not constructed on a uniform plan, and as their contents are subject to great physical and chemical variations, a discrepancy in results is to be expected.

A point to be noted is found in the observation of Dr. Andrewes, that the germs commonly found in sewer air were different from those commonly found in fresh air; from which we may conclude that the former tend to remain where they are—a conclusion eminently satisfactory as tending to the maintenance of public confidence.

Apart from every other consideration, the low incidence of zymotic disease in the British Army at home leads to the common-sense conclusion that a well-constructed drainage system is practically never a source of danger to troops in barracks, and therefore that no evidence has yet been produced which affords the least ground for alarm.

Besides the systems already discussed, sewage is often disposed of in the sea. This is the case at Renmore Barracks, Galway, and at some of the forts between Plymouth and Tregantle, including the latter. Even if the end of the exit-pipe is covered at all states of the tide, filth may be washed up on the shore, and recent researches have

shown that sea-water checks the change of organic into inorganic matter. Even if the sewage has undergone preliminary treatment the system is not without grave disadvantages, as the nitrates and ammonia form nutriment for certain sea-weeds which, ultimately dying and rotting on the shore, cause serious nuisance. These weeds include the *Ulva latissima*, the *Enteromorpha compressa*, and the *Enteromorpha intestinalis*. The first named contains so much nitrogen that it is stated to resemble an animal rather than a plant.*

To sum up preceding statements, we may conclude that, when compatible with existing circumstances, water carriage is the system at which we should aim. Dry earth is a constant menace to health, and affords no satisfactory means of dealing with slop-water from kitchens and sculleries; such water is often allowed to run into catch-pits which are never properly emptied, and which attract large numbers of flies. Imagine a case of enteric fever occurring in a camp where the dry-earth system is in force; it is quite easy to see that, having regard to the unavoidable presence of flies, and to the careless manner in which the dry earth is used, widely-spread disaster may be expected. As an alternative to dry earth, some kind of liquid disinfectant may be used; but this leaves the question of slop-water untouched. On the other hand, the United States excavating waggon would deal with this difficulty, as the catch-pits could be emptied by the pump. In many circumstances the McCall incinerator would prove an effectual solution to the whole problem.

The disposal of refuse other than that of excremental origin must be settled by local conditions, and by the presence or otherwise of specially-designed apparatus. Kitchen refuse can generally be burned by cooks without serious trouble. Burial in the same manner as that mentioned in the case of excreta is sometimes the most suitable

* 'Nuisances caused by Certain Green Seaweeds,' by E. A. Letts, D.Sc., Professor of Chemistry, Queen's University, Belfast (*British Medical Journal*, September 11, 1909).

method of disposal. When sufficient land is available, and when no immediate objections of a practical nature exist, this method has a good deal to recommend it, as it avoids the waste of manurial material. In India, town rubbish is found to be a good top-dressing for the production of grass.* Considerations of this sort cannot, naturally, weigh for a moment when the health of the troops is in question, and in cases of doubt it is the best plan to resort to destruction by fire, as this is absolutely safe. There are many admirable refuse destructors on the market; one of the best appears to be that designed by the Horsfall Destructor Company, Leeds. The following is an account of the two forms of destructor supplied by this company:

'This machine is constructed in two forms—(1) the "wheeled form," (2) the "man-carried form."

'In the first, or wheeled form, the destructor consists of a furnace having a grate of perforated plate, with firing-doors in the front. The casing of the furnace consists of a double tank, in one side of which infected stools, and in the other infected clothing, may be boiled in hot water by the heat of the destructor.

'The chimney is made in sections, which can be packed, between brackets fixed for that purpose, on the top of the furnace for travelling. Large doors are provided on the top of the tanks for access to the tanks, and cocks or valves at the bottom for emptying the same.

'The destructor is provided with travelling wheels and shafts, the latter having the usual props to support the destructor when stationary, and being attached by strong brackets to the tanks.

'In the second, or man-carried form, the furnace and tanks are arranged as above described, but the tanks are made in two or more parts, each forming a separate tank, and bolted together. Each of the sections into which the destructor is so divided is so proportioned as to be a convenient load either for one or two men. Brackets are provided on the sections through which a pole may be passed to enable the load to be conveniently shared between two carriers. To

* 'Farm Manual,' p. 15.

enable wet or foul materials to be more readily burnt, combustible fluids, such as tar oil or petroleum, should be mixed with the refuse, by sprinkling with a watering-can or otherwise. Such fluids may be conveniently carried in drums put inside the furnace or tanks, and taken out when the destructor is to be used.

'The whole machine, except the shafts and wheels, is constructed of light steel plate. The weights are approximately as follows:

> "Wheeled" destructor: Total weight, 18 cwt.
> "Man-carried" destructor: Total weight, 337 pounds.
> Weight of each Section: 94 pounds: 87 pounds: and 62 pounds.'

Portable destructors would have been invaluable in South Africa, and their presence would be an enormous sanitary advantage in many of our foreign stations. The Horsfall destructors appear to be excellently adapted for use in the service, and therefore worthy of an exhaustive trial. A very fair destructor may be improvised by cutting two trenches, about 2 feet deep, at right angles to each other, with a chimney of sods built at the angles of intersection. Within common-sense limits, the higher the chimney the better. A little paraffin helps matters greatly, as it starts the rubbish burning, and, by warming the interior of the chimney and the contained air, it produces a draught which keeps up the fire. Some care has to be exercised in putting on fresh refuse, but if attention is paid to this point, the fire generally burns itself out. A great advantage of this scheme is that the rubbish is burnt in one place, and the process, if in the hands of a reliable man, is kept under proper control.

In the camps round Ladysmith rubbish was burnt anywhere and everywhere, and a most intolerable nuisance was thereby created. As the fires were under no supervision, cartridges were often thrown into them, and serious, and even fatal, accidents were the consequence. This danger, besides others more allied to sanitation, would be prevented by the adoption of a measure such as the preceding.

An enormous amount of ingenuity has been expended by

medical officers in designing improved refuse destructors. On the whole, the above seems to answer as well as any. The design recommended in the 'Manual of Military Sanitation' is a shallow pit lined with stones, with a pyramid of stones in the centre. Stones are not always obtainable, and unless those in the centre are piled loosely, the draught is insufficient; but by using large stones, and by piling them so as to leave wide interstices, a kind of chimney is formed, which is a great help towards combustion. By getting rid of refuse we get rid of flies. These insects live in almost any kind of filth, and they seem to have a particular predilection for fermenting horse-dung. The fly which mostly concerns us is the *Musca domestica*, or common house-fly. 'This insect is distinguishable by having, on the dorsal side of the thorax, four almost black stripes on a dusty grey ground which has a gold shimmer. Its abdomen is buff-yellow, with a dark brown medium dorsal stripe, and the sides of the posterior segments are overspread with a reflecting grey. The average length of the *Musca domestica* is 6 to 7 mm., but dwarf specimens often occur.' * In England the fly usually breeds from May to October. Each female may lay six batches of eggs, with 100 to 150 eggs in each batch. According to the conclusions of Howard, of the United States Department of Agriculture, it may be calculated that, 'allowing 1,000 flies to the ounce, we find that the total produce of one fly at the end of forty days would weigh 810 pounds, or more than five times the weight of a 160-lb. man.'† The connection between the presence of flies and certain intestinal disorders has long been known, and now, from the work of Celli and Hoffman, we learn that these insects can carry tubercle bacilli on their appendages and in their intestinal contents. The usual disinfectants are useless for the destruction of flies, but a mixture known as Paris green, consisting of arsenic, copper, and acetic acid, will destroy

* 'The Biology of House-Flies in Relation to Public Health,' by C. Gordon Hewitt, M.Sc. (*Journal of the Royal Institute of Public Health*, October, 1908).

† 'Flies and Fleas as Factors in Disease,' by J. S. Purdy, M.D. (*Journal of the Royal Sanitary Institute*, December, 1909).

90 per cent. of the larvæ in ashpit refuse.* Better than any form of destructive agent is the maintenance of absolute cleanliness, and this in the service is the goal at which we should aim.

A good deal of refuse collects about tents after meals. Men should be instructed to place all fragments in bully-beef tins, or the like, and removal can be carried out by men told off for conservancy duty. If fragments of food are not collected at once, the chances are they will be trodden into

FIG. 40.—ALLAHABAD TRENCH.
Copied by permission from the 'Farm Manual.'

the soil, and so become a factor in the general pollution of the camp.

It is almost unnecessary to insist that satisfactory refuse disposal is essential if health and efficiency are to be maintained. Without these, military success becomes endangered or is impossible, and this fact cannot be taken too deeply to heart.

* 'Preliminary Report on the Habits of the Common House-Fly,' by Robert Newstead, A.L.S., F.E.S., etc., School of Tropical Medicine, University of Liverpool (*Journal of the Royal Sanitary Institute*, February, 1908).

CHAPTER XIX

METEOROLOGY

METEOROLOGY is the study of those physical conditions, existing at different times in the atmosphere, which go to constitute what is known as weather. Anything approaching a complete account of these phenomena would be impossible at present, but some knowledge of the same should be a help to officers in forecasting certain conditions affecting health, and so affording a guide to precautions which it may be necessary to take.

The conditions to be investigated may be summarized briefly as follows: 1. Temperature; 2. Pressure; 3. Wind; 4. Moisture; 5. Rainfall; 6. Ozone; 7. Sunshine.

1. TEMPERATURE.

The temperature of the air is measured by means of two thermometers, viz., maximum and minimum.* The former registers the highest, and the latter the lowest, temperature reached within a given time. The maximum thermometer consists of a column of mercury in a glass tube with a bulb at the lower end, the column of mercury being partly interrupted by either a contraction of the glass or else by a bubble of air. In neither case can the mercury, after expansion, return to its original position until the instrument has been reset; the latter operation merely consists in lowering the bulb, and accompanying the action by a sharp tap or a swing. In the minimum thermometer the column consists

* The illustrations of thermometers in this chapter are reproduced from designs kindly furnished by Messrs. Negretti and Zambra, E.C.

of spirit, a metallic index being immersed in the fluid. As the temperature falls the spirit contracts, and by capillary action it draws the index towards the bulb; as the temperature rises the spirit of course expands, but flows past the index without moving it. The end of the index farthest from the bulb thus indicates the lowest temperature reached. The instrument is reset by raising the bulb, and allowing the index to fall to the end of the column of spirit. In these thermometers Fahrenheit is the scale commonly used in England.

Six's thermometer combines the means of registering a maximum and minimum temperature in a single instrument.

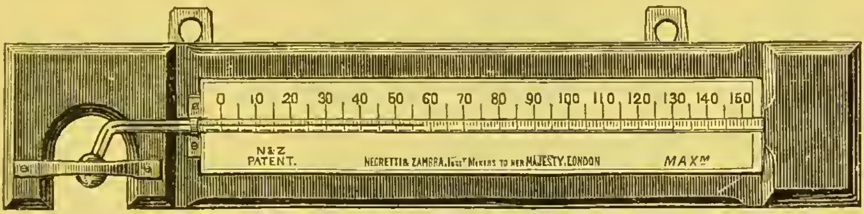


FIG. 41.—MAXIMUM THERMOMETER.

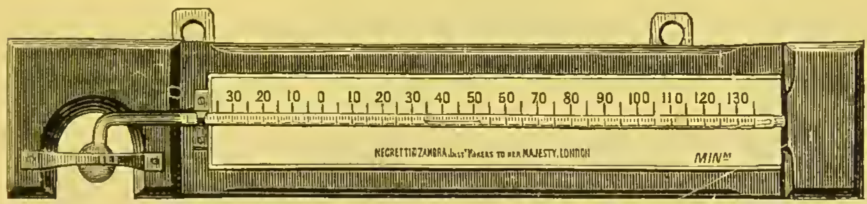


FIG. 42.—MINIMUM THERMOMETER.

It consists of a U-shaped tube, of which the bend and part of each limb are filled with mercury; at the top of the left-hand limb is a bulb which, together with the portion of the limb above the mercury, is filled with alcohol. The top of the right-hand limb ends in a small chamber also filled with alcohol, with the exception of the space occupied by a bubble of air; the limb likewise being filled with alcohol as far as the mercury, in the same manner as on the left-hand side of the instrument. On top of the mercury on each limb is a metallic index. When the alcohol in the bulb expands under the influence of heat, the left-

hand column of mercury and alcohol is pushed down, and the right-hand column is naturally pushed up; when the alcohol contracts a reverse action takes place, the pressure of air in the chamber forcing the column of mercury and alcohol downwards as the pressure in the bulb decreases. The two indices remain in the positions to which they have been carried by the mercury: the lower end of the index in

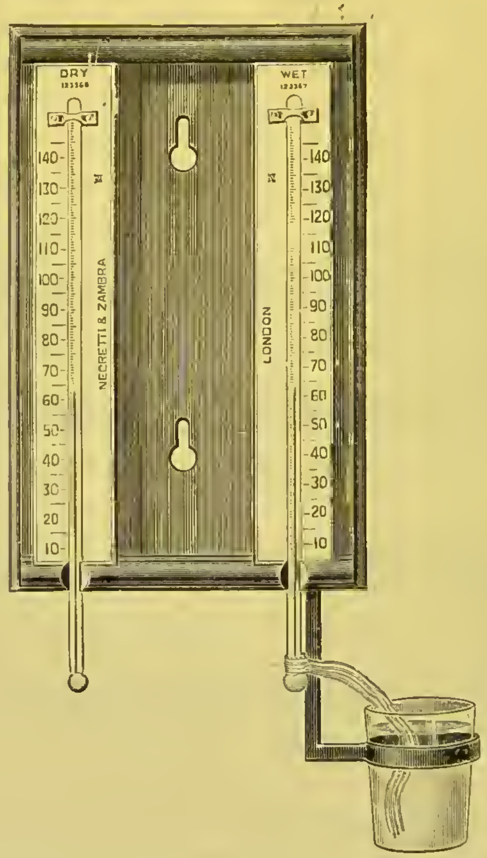


FIG. 43.—WET AND DRY BULB THERMOMETER.

the right-hand limb indicating the highest temperature reached, while the lowest temperature on the other hand is indicated by the lower end of the index in the opposite limb. By means of a magnet the indices can be drawn down to the top of each column of mercury, and the instrument is thus reset. The above is a very old type of thermometer, and, although useful, is almost discarded for scientific purposes. It was invented in 1781.

The thermometers should be kept in a louvred box, about 4 feet above the ground, so as to obtain the effects of the air-temperature only, by the elimination as far as possible of disturbing influences.

Two other thermometers are in common use, viz., the solar radiation and the grass minimum. The former, which is designed to measure the intensity of solar radiation, is a maximum thermometer enclosed in a glass bulb from which the air has been exhausted; the bulb of the thermometer itself is blackened in order to obtain a maximum of heat absorption. The minimum thermometer is supported close to the ground, about on a level with the top of the grass; it measures the loss of heat from the earth by radiation. Loss by radiation is checked by the presence of clouds, as the latter radiate heat to the earth just as the earth radiates heat to them. The loss by radiation, therefore, is greatest in clear weather, when atmospheric humidity is naturally least, and the difference, consequently, between the reading of the solar radiation thermometer and the grass minimum thermometer will be largely dependent on the degree of moisture present in the air (see pp. 386 and 410).

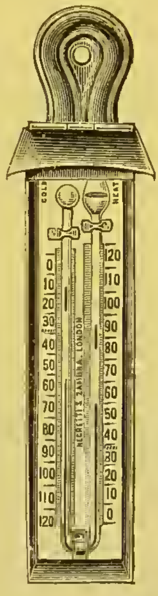


FIG. 44.—SIX'S THERMOMETER.

The mean temperature of the day is obtained from the maximum and minimum air thermometers in one of the following ways:

1. By continuous photographic record.
2. By the mean of two readings at twelve-hour intervals.
3. By a single reading at 9 p.m., or at 9 a.m. For many reasons the last-named, for army purposes, is the most convenient; it consists in taking the mean of the maximum and minimum temperatures observed; the former refers to the previous afternoon, the latter to the same morning. At midsummer the mean of the maximum and minimum recorded temperatures is often 2° or more too high.

To understand the meaning of the readings, it should be

explained that the radiant heat of the sun does not warm the air, but that the latter is warmed by conduction from the earth, rock, buildings, etc., which have already derived warmth from the above source.

At Alpine winter resorts the heat of the sun makes it easy to indulge in outdoor amusements in comparatively light garments, although the air minimum thermometer registers many degrees of frost; while immediately after sunset extra covering becomes a necessity, showing that the warmth during the day is derived directly from the solar rays. It must also be explained that watery vapour obstructs the passage of dark heat rays, and as the bright rays

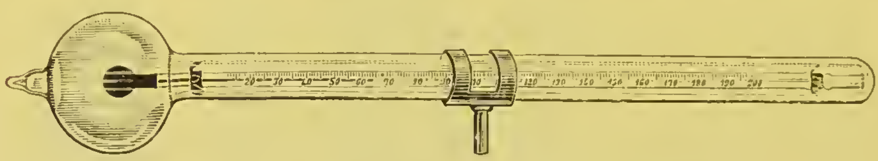


FIG. 45.—SOLAR RADIATION THERMOMETER.

FIG. 46.—GRASS MINIMUM THERMOMETER.

of solar heat are in part converted into the latter on reaching the earth, it will be seen that the vapour in the air acts as a heat-trap, on the same principle as the glass of a greenhouse. Another factor in determining the amount of heat received by the earth is the effect of watery vapour in the air in checking the passage of heat from the sun (see p. 401). It must be understood that heat is not the same thing as temperature, as the latter only signifies the amount of heat which can be recorded by the means described. The temperature of water can only be raised slowly, with the result that, though the ocean absorbs an enormous quantity of heat, its temperature is fairly constant. Isotherms are lines drawn through spots

of approximately the same temperature, and reference to maps in which these lines are indicated will show that the latter maintain a regularity on the sea which contrasts strongly with the irregularity they display on land, proving that the land loses and gains heat with a rapidity that is wanting in the sea; in fact, it is easy to perceive that the temperature of the land may exceed that of the ocean, while the latter actually possesses the greater amount of heat (see p. 403).

2. Pressure.

As the air possesses weight, and as the lower strata are pressed down by those above them, it follows that the weight of the air will diminish in accordance with the height to which we ascend; also, as the air contracts under the influence of cold and expands under the influence of heat, the weight must vary according to the temperature of any given locality. Air weighed under identical conditions of temperature and pressure will give identical results; in short—to be accurate—the weight of air is always the same: it is the amount present which varies. The pressure caused by the weight of air is measured by the barometer. Reduced to its simplest expression, a mercurial barometer, the only kind considered here, consists of a glass tube filled with mercury, and inverted over a trough containing the same metal.

The mercury sinks until the column is counterbalanced by the weight of the air, and as the weight of the air varies, it follows that the height of the mercurial column must vary in accordance.

As the column sinks the mercury in the trough must, of course, rise, and this leads to difficulty of measurement. This difficulty is obviated in Fortin's barometer, the one best adapted for service use, by means of a cistern with a leather bottom, instead of the ordinary trough; the leather bottom can be raised or lowered by means of a screw, and the surface of the mercury in the cistern can thus be accurately adjusted to the level of a fixed ivory point, known

as the 'fiducial' point, which serves as a standard from which the height of the column must be read.

Accuracy in reading is obtained by means of a vernier, the latter being a movable scale attached to the side of the barometer. The barometer is graduated in $\frac{1}{20}$-inch divisions, twenty-four divisions of the barometer corresponding to twenty-five divisions of the vernier. It follows that if one division of $\frac{1}{20}$ inch was divided into twenty-five equal parts of 0·002 each, and each part was added to each vernier division, then the latter would also each measure $\frac{1}{20}$ inch; from which it is clear that each vernier division is 0·002 inch less than each barometric division.

To read the barometer, the bottom of the vernier is adjusted so as to correspond with the top of the mercurial column. If the bottom of the vernier is on the same level as one of the barometer marks, no further calculation is necessary; but if there is a difference of level, we must note the next highest vernier mark which has a corresponding mark on the barometer scale. Supposing this corresponds to the top of the fourth vernier division, counting from the lower end of the latter scale, then $0·002 \times 4 = 0·008$ inch must be added to the mark on the barometer scale above which the mercury stands.

The following example may help to explain the method of observation: Suppose the mercury stands above 29·25 inches, but below 29·30 inches, and that the tenth mark from the lower end of the vernier scale corresponds to a mark on the barometer scale; then—

$$0·002 \times 10 = 0·02;$$
$$0·02 + 29·25 = 29·27 \text{ inches,}$$

which is the true reading.

The actual observation is made as follows: The temperature is first taken by the attached thermometer; the level of the mercury is accurately adjusted to the fiducial point, so that the latter touches its reflection in the mercury, and the vernier moved until its lower edge cuts off the light from the

top of the mercurial column. Certain corrections must be applied. These are—

1. For inaccuracies in the scale.
2. For capillarity, which tends to depress the mercurial

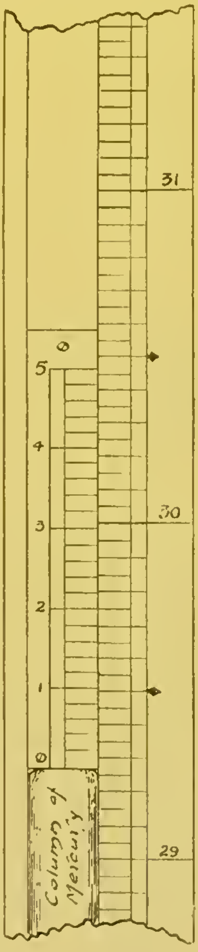


FIG. 47.—BAROMETER SCALE WITH A VERNIER READING OF 29·27.

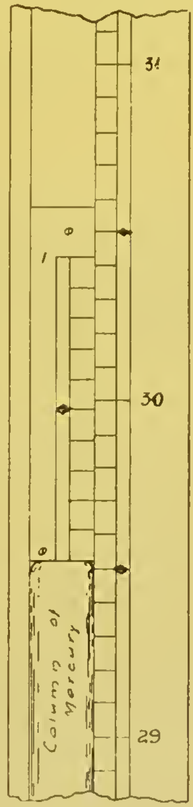


FIG. 48.—SIMPLIFIED BAROMETER SCALE WITH A DIRECT VERNIER READING OF 29·52.

From sketch by Quartermaster-Sergeant Revill, R.E.

column. The corrections are obtained from Kew certificates. Corrections are also required for temperature and elevation, the respective readings being reduced by means of tables of corrections to 32° F., and to the mean half-tide

level at Liverpool. For the last purpose it is also necessary to know the height of the station.

A simplified scale with direct reading is shown in Fig. 48.

In the tropics the barometric changes present a regularity which is unknown in the British Isles. There are two maxima—viz., about 9 a.m. and 9 p.m.—and two minima —viz., about 3 a.m. and 3 p.m.; the last named is probably due to expansion of air at the hottest time of the day, while the causes of the remainder present some intricate considerations which need not be discussed at present.

3. Wind.

Winds are caused by the existence of unequal weights of different volumes of air, the heavier volumes rushing towards the regions occupied by the lighter. As air expands by heat, and in so doing loses weight, it follows that there must be a constant inrush of air to the hottest parts of the globe—namely, to those situated nearest to the equator—the colder, and therefore heavier, air from northern latitudes taking the place of the warmer and lighter air of the equatorial regions. As the incoming air tends to maintain the speed of rotatory movement belonging to the latitudes from which it started, and as the rate of rotation regularly increases from the poles to the equator, it is plain that, as winds from the north or south approach the equatorial line, they must be travelling eastward at a slower rate than that at which the planet is rotating in the same direction.

An observer standing near the equator and looking to the east would have a wind constantly blowing in his face, or, to put it more correctly, he would receive the impression of a wind blowing in his face, such an impression resulting from the fact that he was surrounded by air moving, it is true, in the same direction as himself, but considerably slower. The wind, in fact, would appear to come from the north-east or south-east, according as the observer was standing north or south of the equator. These winds are known as the north-east and south-east trade-winds (see p. 409).

The further direction of these currents of air may now be considered. The light and hot air on and about the equator is forced upwards by the inrush of heavy and cold air from low latitudes, loses heat as it ascends, and, in virtue of its consequent contraction, gains weight to a corresponding extent, and therefore sinks again towards earth. On rising from the equatorial zone it flows north and south, travelling this time with part of the rotary speed belonging to the equatorial latitudes, and as the course is into regions where the speed of rotation is diminished, the wind consequently blows in an easterly direction in either hemisphere. In the Northern Hemisphere these air-currents gain our coasts in the form of the warm and moisture-laden south-westerly winds, which are such well-known features of Devon, Cornwall, and the West of Ireland. These return currents of air have been styled by Sir John Herschel as 'the anti-trades'; this name is, of course, applied to the winds of both hemispheres. It should be understood that the above sequence of events does not follow with the regularity which preceding statements seem to imply, the presence of land and the changing seasons being disturbing elements, the effect of which is too lengthy a subject to be entered on here. It may, however, be explained that in the summer the south-east trade-winds are drawn across the equator by the low pressure of the rarefied atmosphere, caused by the heated plains of Northern India and other parts of Asia lying in the same latitudes. As the land in these regions rises in temperature, so must the air above them expand as it gains heat by conduction from the surface of the earth, colder and heavier air naturally rushing in at the same time to take its place, and the colder air is represented by the south-east trade. This wind gains the same rate of rotation as the general mass of air at the equator, and is consequently deflected to the east after crossing the line, in a manner already explained in connection with the anti-trades, and in the Northern Hemisphere becomes the south-west monsoon.

Winds may be conveniently divided into moist and dry. Among the former are the winds which have just been

discussed, and among the latter are the hot winds of Egypt and Northern Bengal, while examples of cold dry winds are found in the east winds of our own country.

As a general statement, a wind may be said to carry with it the temperature and moisture of the region from which it comes, and we have therefore, in view of the difference in connection with heat absorption by land and water respectively, a ready explanation of the contrast between the prevailing winds of our east and westerly coasts. In the former case the air-current reaches us from the cold northern latitudes of the Continent, and in the latter it brings to us the equatorial heat lowered by its journey over some thousands of miles of Atlantic Ocean at a comparatively equable temperature, the lowering of the temperature of the wind being caused by the amount of heat rendered latent to hold in suspension the vapour from the surface of the ocean (see p. 327).

Land and sea breezes are familiar phenomena, and their occurrence is, in general terms, due to the following causes. During the day the land, owing to its low specific heat, rises in temperature more rapidly than the sea, and the lower strata of air, becoming heated by conduction, rise, and at the same time expand. An area of low pressure is thus formed, and, to re-establish equilibrium, the colder and heavier air over the ocean rushes in to replace the air which has risen from the land. At night the above conditions are reversed: the land cools the more rapidly, and the air above it, cooling and contracting, flows seaward to replace the warmer air which has risen from the surface of the ocean. It will easily be seen that the sea breeze is a damp, and the land breeze a comparatively dry, wind.

In mountainous regions a similar sequence of events is a matter of common observation.

'A somewhat similar reversal of atmospheric motion in the daily period is well known in mountainous countries, except in very high latitudes. In Europe the winds thus arising are known by local names, which are often different in closely contiguous districts; this is especially the case

in the neighbourhood of the Italian lakes The phenomena are as follows: About 9 or 10 a.m. a wind, the day wind, begins to blow up the valleys, freshens till the afternoon, and dies down at sunset, when, after an interval, it is replaced by a counter-current, the night wind, blowing down the valley. These are so regular that any interruption in their daily alternation is well known as a sign of coming bad weather, for great atmospherical disturbances interfere with the progress which I am about to describe, and which, according to Dr. Hann, constitutes the true explanation of the phenomenon.

'The day wind brings up moisture to the upper strata of the atmosphere, and this is condensed, forming caps on the mountain-tops and often giving rise to thunderstorms. The night wind, a descending current, carries the moisture down with it, and so the highest peaks are oftenest clear in the early morning.

'The reasons of this rhythmical change in air motion are to be sought for in the action of heat. In the daytime the air in the valleys and on the lower slopes of the mountains becomes heated and expanded. The isobaric surfaces over such districts rise, and the air so raised has a tendency to flow towards the mountains and up the upper valleys as long as the heat action over the lowlands is maintained. At night the temperature in the valleys falls, and the air lying in them contracts, producing a partial vacuum. This causes the air above to descend, so that a downward current is generated, which lasts all through the night.' *

The effects when a warm, moisture-laden wind meets a chain of mountains are important. The air-current is naturally forced to ascend; as it ascends it becomes cooler by expansion and consequent disappearance of sensible heat, while the contained moisture is deposited in the form of cloud, and often of torrents of rain (see p. 402). After crossing the summit of the range it descends by force of gravity, and the latent heat which had held it in a state of expansion is now forced out of it by the pressure of the superincumbent atmosphere,

* Scott, 'Elementary Meteorology,' p. 288.

and the final result is the production of a warm, dry, and intensely disagreeable wind. The Föhn in Switzerland is a wind of this character. When the air, after rising to the summit of a range, meets with a tableland, the results are different : it does not descend, and consequently does not contract, and having deposited its moisture, and at the same time parted with its sensible heat, in the manner explained, it is felt a cold, dry, and bracing wind. This circumstance may in part explain the extremely healthy climate of the high veldt. For instance, after crossing the range of the Drakensberg, which intervenes between Natal and the Orange River Colony, the descent from Van Renan's Pass to Harrismith is comparatively slight, and for a bracing health resort the latter should have few equals.

Another example of the effects of a range of mountains on winds is found in the case of certain districts in the North of Scotland. The conditions are described as follows in Scott's 'Meteorology' :

'Some localities are specially favoured, even though they do not lie on a south coast, as, for instance, the coasts of Moray Firth, Nairnshire, and the Carse of Sutherland. These districts owe their good fortune to the fact of their lying on the lee side of an extensive mountain district. The prevailing winds, being westerly, deposit their moisture on the Atlantic slopes of the hills, and the air, thus drained of its moisture by ascent, is further dried and warmed by its descent to the sea-level on crossing the island. The atmosphere of these districts is therefore essentially drier than that of other places in the same latitude, and the dryness, inducing clearness of the sky, allows more frequent access to the sun's rays than is possible on the cloudy west coast.

'Accordingly, crops will ripen in the valley of Shin, in Sutherlandshire, in 58° N., which never come to maturity in Argyllshire, two degrees farther south.'*

Wind is measured by means of anemometers.

The instrument in common use is Robinson's.

It consists of four light arms, each of which is furnished at

* Scott, 'Elementary Meteorology,' p. 345.

FIG. 49.—SCENE IN THE DRAKENSBERG, FROM THE NATAL SIDE.
The summit forms the raised fringe of the tableland of the Orange River Colony. Condensation is seen taking place among the peaks.

the end with a hemispherical cup ; the cups receive the pressure of the wind, and the arms are thus made to rotate, the movement being transmitted to a series of recording dials

4. Moisture.

The capacity of dry air for holding moisture increases with the temperature, but with far greater rapidity. Air is said to be saturated when any fall of temperature leads to the deposition of moisture. Air is never completely free from moisture, and the temperature at which condensation takes place is known as the 'dew-point.' The above term is a good one, as dew, or condensed atmospheric moisture, is deposited as soon as the radiation from the earth has cooled down the lowest strata of air below the temperature at which such moisture can be held in the form of vapour.

It is often an important matter to determine the dew-point, the latter, of course, varying according to the air-temperature and the quantity of moisture present. Several instruments have been designed for this purpose, but in the army the wet and dry bulb thermometer is the only one in use; it consists of two ordinary thermometers placed side by side, the bulb of one being covered with muslin or other light material, and kept constantly moist. Evaporation from the muslin causes a certain amount of heat to become latent, with a consequent lowering of the temperature of the bulb and a corresponding fall in the mercury. As long as evaporation continues, so long will the wet bulb thermometer record the lower temperature, but if the air is saturated, no further evaporation is possible, and the temperatures recorded are therefore equal (see Fig. 43).

By reference to Glaisher's tables the dew-point is ascertained from the temperatures observed, the tables also stating the weight or tension of aqueous vapour for a series of given temperatures ; but what is actually more important than either of the above is the relative humidity or the drying-power of the air. This can also be found by Glaisher's tables, or else by calculation as follows :

Weight of a cubic foot of vapour at dew-point and weight of cubic foot of vapour at dry bulb temperature are first ascertained from the tables; the former is used as a numerator and the latter as a denominator, and the fraction is multiplied by 100, thus:

$$\frac{\text{Weight of cubic foot of vapour at dew-point}}{\text{Weight of cubic foot of vapour at dry bulb temperature}} \times 100 =$$
relative humidity expressed as a percentage of saturation.

Of course, the higher the percentage the less the drying-power remaining, and *vice versa* (see p. 409).

Fogs, mists, and clouds are identical in their nature, and consist of the condensation of watery vapour on solid particles. The presence of quantities of carbon in the atmosphere accounts for the frequency of fogs in many of our large manufacturing towns. At sea the solid matter exists in the form of salt, and possibly of meteoric dust. Aitken believes that the atmosphere is polluted by dust resulting from human agency, and carried upwards by heated air-currents.

5. Rainfall.

Rain is caused by the chilling of the atmosphere to an extent which renders it impossible for the contained vapour to remain as such, and the latter is therefore condensed into water, and falls to the surface of the earth. The principle of rain formation has a familiar illustration in the deposit of moisture on the hand if the latter is held in the vapour issuing from a tea-kettle or other vessel of the same kind. Under the conditions of nature there are three principal ways in which condensation comes about:

'1. The ascent of a current of damp air, which is chilled by expansion as it rises.

'2. The contact of warm and damp air with the colder surface of the ground, as in the case of our own west coasts in winter, when the land is colder than the sea surface.

'3. The mixture of masses of hot and cold air.' *

* Scott, 'Elementary Meteorology,' p. 136.

The first of these is the most important.

Cloud-covered mountain-tops are objects of common observation. The lower slopes of the island of St. Helena are barren and uninviting, while the higher districts, where the rainfall is heaviest, are clothed with abundant vegetation, which itself is, in turn, a direct cause of the condensation of atmospheric vapour. To those who have lived in Bengal the contrast between the comparatively treeless plains and the wooded slopes of Mussoorie and Naini Tal is sufficiently familiar. It is the contact of the warm moisture-laden westerly winds with the colder land that accounts for the heavy rainfall in the south-western counties of England and the West of Ireland, and gives to these parts some of their pleasing characteristics. In the eastern counties the average rainfall is about 20 inches per annum, and in the West of England about 80 inches, but the latter amount is largely exceeded in certain localities.

Apart from the purely æsthetic point of view, the practical effect of the heavy rainfall in the West of England and Ireland is found in a variety of dairy and other produce, which stands unrivalled in the British Isles. The heat which kept the moisture of the air in a state of vapour is set free as soon as condensation of the latter into rain, consequent on the cooling effects of the land, takes place. The heat being now free, a rise of temperature occurs, and this fact is one explanation of the comparatively mild climate of the above-named regions. To use a scientific expression, 'latent becomes sensible heat.'

Rainfall is measured by means of a gauge, the latter consisting of a metal funnel leading to a receiver. The amount collected is greatest at the ground-level. The site must be an open one, and the gauge must be kept as upright as possible. The area of the funnel in square inches must be accurately known. Suppose it is 144 square inches, then it is evident that 144 cubic inches collected in the receiver will represent 1 inch of rain; so that, by means of a graduated glass into which the rain collected during a given time is measured, the quantity which has fallen in this time can easily be calculated.

6. Ozone.

Ozone is simply condensed oxygen, three volumes of oxygen forming two volumes of ozone. It is produced from the oxygen in the air by atmospheric electricity. Its detection depends upon the power of the gas for liberating iodine from iodine of potassium, the iodine striking a blue tint in a solution of starch. The test is not a sure one, as both chlorine and nitrogen tetroxide have the above effect. In our present state of knowledge the subject has not any particular value.

7. Sunshine.

The duration of sunshine is recorded by means of a special apparatus; but for service purposes these means need not now be considered, as, although the subject itself is one of importance as affecting the health of troops, observation and records do not come within the general scope of military duty (see p. 402).

CHAPTER XX

CLIMATE

CLIMATE may conveniently be defined as the sum total effect of natural conditions on any given locality. The principal controlling influences in determining climates are—

1. Distance from the equator.
2. Height above the sea.
3. Distance from the sea.
4. Prevailing winds.
5. Local conditions, such as nature of soil, vegetation, proximity to hills, etc.

1. Distance from the Equator.

Speaking generally, the nearer a place is to the equator the hotter it will be. The solar rays here fall more vertically on our planet than at any other part of its surface; it follows that these rays have a shorter distance to travel through the air than those which are directed to latitudes nearer the poles. The watery vapour in the air checks the passage of solar rays to an extent proportionate to that to which its own temperature is raised by the rays in question; and it is therefore easy to understand that the thicker the layer of atmosphere to be traversed, the less the amount of heat which will ultimately be received by the earth (see also p. 386).

Of course, there is no steady and continuous diminution in temperature on proceeding from the equator to the poles. The unequal distribution of land and water prevents anything of the kind, and we therefore find on the same

latitude places with widely different climates; while, as a matter of fact, the line of greatest heat is not at the equator itself, but at some distance north of it.

2. Height above the Sea.

The effect of elevation on climate is interesting. It is a matter of common observation that the air feels colder the higher we ascend. The more elevated strata of the air are correspondingly free from superincumbent pressure, and so naturally expand. The expansion is accompanied by a disappearance of heat, for the reason that the heat is now engaged in forcing the air particles away from each other, and consequently it cannot make itself otherwise felt (see p. 393). Cold air is unable to retain moisture, and the latter is therefore deposited in the form of cloud or rain; so that above the region of clouds the air is cold and dry, and the rays of the sun, being unimpeded, have their force correspondingly intensified. Strong sunshine and cold and dry air are, therefore, characteristics of mountainous regions. The blistering effects of the sun are fairly familiar to those who have served on the high veldt.

Moisture retards radiation, so that at great heights radiation is comparatively unchecked, and loss of heat by this means may account for the fact that, in spite of the force of the solar rays, sunstroke in elevated regions, such as the Orange River Colony and the Transvaal, is practically unknown.

The above rule as to the fall in air-temperature at increasing heights is, however, not absolutely invariable. Cold air has, in virtue of its weight, a natural tendency to sink, so that it is sometimes actually warmer during a frost on the top of hills than it is on the plains below, the difference of temperature sometimes resulting in a thaw on the hills while there is a frost at the lower level. This phenomenon is known as the 'up-bank thaw.'

Another factor which makes for the lower temperature of elevated regions is that the latter are less sheltered than those at lower levels, and therefore more exposed to the chilling influences of the wind.

3. Distance from the Sea.

This matter was referred to in the previous chapter, but now necessitates more detailed mention. The influence of the ocean may be summed up in a general statement to the effect that the less land and the more water the fewer will be the changes in temperature. This fact is explained by the comparatively large quantity of heat which is required to raise the temperature of water as compared with that of land generally, a truth that is expressed by saying that water has a high specific heat, the term 'specific heat' meaning the amount of heat which various bodies respectively absorb when they rise in temperature. Water is taken as unity, and all other bodies are compared with it. For instance, if a pound of water and a pound of mercury were exposed to exactly the same temperature for exactly the same time, the temperature of the mercury would be as nearly as possible thirty times higher than that of the water; that is to say, it takes about thirty times more heat to raise water than mercury to any particular degree. The specific heat of water is therefore said to be thirty times that of mercury. These figures are usually stated in decimals. The decimal corresponding to $\frac{1}{30}$ being 0·03, the specific heat of mercury is stated to be 0·03, the specific heat of water, as already explained, being taken as unity, or, in other words, as 1 (see pp. 386 and 419).

It follows from the above that the sun can beat a long time on water before the latter becomes unpleasantly hot, a fact which accounts for the comparatively equable temperature of the ocean. If the specific heat of water were raised to that of sand, ocean voyages would lose their most pleasant characteristics; sea-bathing would be impossible; fish would be unable to exist near the surface; and the heat of the atmospheric moisture would soon render the world uninhabitable. The reason of the tempering effects of the ocean should now be apparent. It may conveniently be stated, in general terms, that the more the land the greater the reception of heat in any given time, and the greater its

subsequent loss; the more water the less the reception of heat in any given time, and the less its subsequent loss. Insular countries are thus placed under particularly favourable conditions in connection with changes of temperature, and those who have passed summer and winter in both New York and London are in a position to realize certain advantages of the 'dreadful English climate,' and the climatic possibilities of a huge continent.

The evaporation going on from the surface of the ocean must, in a manner explained elsewhere, lower the temperature of islands or of localities generally which are near a sea-coast.

4. Prevailing Winds.

The cause of winds has been explained in the preceding chapter ; it is, therefore, only necessary to state that climate must largely depend on the nature of the prevailing winds, in view of the fact, already stated, that a wind tends to bring with it the temperature and moisture of the region from which it comes. The effect of a wind crossing a mountain range has already been discussed in some detail.

5. Soil and Other Local Conditions.

Soils vary greatly as to their specific heat, the latter being raised, as might be supposed, by the presence of water. Damp clay soils are usually spoken of as cold soils (see p. 420). Sand, on the contrary, rapidly absorbs heat, and rapidly loses it again by radiation when the source is withdrawn.

In Upper Egypt the effects of the withdrawal of heat after sundown are remarkable. So rapid, indeed, is radiation, aided by the cloudless atmosphere, that sleeping out without extra covering is productive of a degree of discomfort suggestive of being steadily frozen alive. It was no uncommon circumstance, during desert marches, to see men, who were unable to sleep from the cold, prowling about in the small hours of the morning in the vain hope of getting warm. During the day the conditions were so far reversed that the intensely-

heated sand raised the temperature of the lower strata of the atmosphere to a degree approximating to that of the air from a blast-furnace.

Herbage and trees have a cooling effect upon the soil, both by their shielding action against the rays of the sun and also by increasing evaporation. As already explained in connection with clothing, heat which is holding vapour in suspension is not perceptible to our senses, and is, for the time being, subtracted from the sum total of that available for raising the temperature of matter generally. The water from the leaves is readily evaporated under suitable conditions, and heat being thus rendered latent, a rapid reduction of temperature ensues (see p. 327).

Hills affect localities in their neighbourhood by sheltering from winds, or sometimes by cutting off sunlight. The Malvern Hills, for instance, lie almost north and south, so that Great Malvern, which is on the eastern side, is in gloom while the Herefordshire side is bathed in sunlight.

The effect on the human organism of certain of the conditions which have been named now requires discussion.

(*a*) Temperature.

As affecting the well-being of man, temperature is certainly the most important factor in connection with climate.

'Not merely is its action on the organism more direct than that of any other factor, but indirectly it affects other factors in such a way as to determine their character to a large extent' (Huggard).

In the chapter on Food, it was explained that the animal organism may be compared to an engine, of which the food we consume is the fuel, and that the act of burning, by which the temperature of the body is maintained, is the result of the union of the food with the oxygen of the air. It was formerly held that the altered food circulating in the blood united with the oxygen drawn from the air into the lungs. We now know that this is an error, and that the burning takes place, for the most part, in the muscles.

Richet calculates that 90 per cent. of the heat of the body is produced as above during contraction, and 75 per cent. during rest.*

It has been calculated that if no heat-regulating mechanism was in existence, a person weighing 10 stone would reach the temperature of boiling water in thirty-five hours ; as a matter of fact, any such disastrous result is rendered impossible by the constant loss of heat from the skin by evaporation, radiation, and conduction.

Suppose that the temperature of the atmosphere is raised, loss by radiation and conduction is checked ; but as the bloodvessels of the skin dilate under the influence of heat, the activity of the sweat glands comes into play, and evaporation of the resulting moisture and consequent cooling of the surface re-establishes the balance. Suppose, on the contrary, the temperature of the atmosphere falls, then, in order to check the loss of heat from the surface, the blood-vessels of the skin contract, with the result that a greater volume of blood circulates through internal organs, and so increases the chemical change, which, as we have just seen, is the main source by which the heat of the body is maintained. As a sequence of the above, it might be expected that the general activity of vital processes would be stimulated by cold and lessened by warmth, and this expectation is borne out by scientific research. Rattray, for instance, found that in the tropics there was 12 per cent. less of carbonic acid removed from the body by the lungs than was the case in England. Edwards and Letellier found that the elimination of carbonic acid diminished in a fixed ratio to the increase of temperature. Crombie, Birch, Rattray, Becher, and others have pointed out that the temperature is, within certain limits, dependent on that of the atmosphere, the increase, according to Becher, being in the proportion of 0·05 for every 1° F. of the atmosphere. It is now easy to see the reason for the frequency of disordered digestion among old East Indians addicted to the pleasures of the table, the excess of food bringing about chemical changes in excess of

* 'Dictionnaire de Physiologie,' art. 'Chaleur,' p. 168.

the requirements of the body, and the effect would doubtless be intensified by the hyperæmia of the abdominal organs known to be commonly present among Europeans resident in India; and this raises the question as to how far the soldier's dietary in the East may be a powerful factor in the production of disease.*

Judging by the observations of Rattray and others, we may conclude that Nature makes an effort to adapt the organism to the conditions of temperature, but that by errors in habits of life her good intentions may be frustrated by the beings whom she endeavours to benefit. Violent exercise, as is well known, increases the heat-production of the body by increasing the flow of blood through the heat-producing organs, and when, owing to the high temperature of the atmosphere, there is insufficient cooling from the skin, the balance between production and heat is disturbed, and untoward consequences are the result. Personal experience leads me to believe that, as a general rule, physical exercise is necessary for the maintenance of health in hot climates, but that the exercise should not be taken in the heat of the day. If the exercise is taken after sunset, or thereabouts, increased heat-production is counterbalanced by loss of heat from the surface, and so the natural equilibrium is maintained. Exercise, by inducing dilatation of the surface-vessels and free perspiration, counteracts the tendency to internal congestion, and thus relieves the strain on the abdominal viscera. The free use of alcohol, on the other hand, acts as an irritant to the digestive tract, and therefore tends to produce the state of congestion which it should be our object to avoid.

Febrile attacks are very common amongst new arrivals in hot countries; as a rule, the trouble subsides easily. An explanation of the above is found in the fact that the heat-regulating mechanism is set for a certain temperature, and cannot immediately adapt itself to sudden changes of

* 'Lunus Consumption of Proteids and Enteric Incidence,' by Lieutenant-Colonel G. S. Thomson, I.M.S. (*Journal of the R.A.M.C.*, February, 1910).

climate. In connection with this subject Dr. Huggard of Davos, whose experience of climatic therapeutics is probably unsurpassed, writes as follows:

'Another important factor in determining the individual reaction has still to be pointed out—the influence of habit. The heat-producing apparatus may be set or arranged for a given output. As we have seen, a person in the tropics exhales less carbonic acid than a person in the Arctic regions; and when the conditions are suddenly changed, the organism requires to adapt itself to its new circumstances. The good and evil effects alike of a change of climate turn largely on this point. The altered conditions stimulate or relax the energy of various organs. If a demand for increased heat-production be made, the result varies according as the demand previously was up to the limit of endurance—of supply—or not. If the organism can easily adapt itself to its new surroundings, and make heat up to the altered requirements, the effect is bracing or tonic. If, on the contrary, the demand is already up to the heat-producing power of the organism, the influence is depressing; the various organs, in proportion to their activity, suffer from impaired nutrition, or nutrition below the present needs of the organism. Now take the opposite case. Suppose the demand for oxidation is lessened, what happens? Here again are two cases. If, previously to the change, oxidation was hardly up to the level of the requirement, as in the case of a person of low vitality in a cold climate, the effect is tonic or bracing. The oxidation having previously been insufficient to keep up the heat of the body, all the functions are better performed in the less exigent circumstances. If, however, oxidation was easily performed to the full extent of the demand in a cold climate, the diminished removal of heat that occurs in a warm climate causes a sense of oppression, and the climate is spoken of as relaxing.'*

* 'A Handbook of Climatic Treatment,' by William R. Huggard, M.A., M.D., F.R.C.P. P. 164.

(*b*) Pressure.

The effect of pressure on the body is not a matter that has any very practical connection with our subject. It is true that palpitation and breathlessness are sometimes complained of by new arrivals from the plains at stations like Mussoori and Naini Tal, and I have heard of the same thing in Alpine resorts. The symptom soon disappears in healthy people, and beyond that it suggests discretion in 'khud' climbing and other forms of hard exercise, it is of no importance, except in actual disease of the heart.

(*c*) Wind.

The principal effect of wind is its power of abstracting heat from the body. The skin tends constantly to lose heat by conduction to the surrounding air, and when successive portions of the latter are rapidly heated from this source, the loss to the body must be considerable. When air is still, an approximate balance is established, and tends to remain constant.

During a voyage to or from the Cape a knowledge of the trade-winds may be of value. While running before the winds in either hemisphere the conditions of life on board ship are unwholesome and disagreeable: heat is excessive and ventilation almost nil; but when the contrary wind meets the ship the conditions are entirely reversed. On the southward run the cold south-easter, blowing straight from the Antarctic region, is apt to be rather trying after several days of hot and relaxing weather, and it is a mistake to pack away warm clothes, even during the Cape summer, with the idea that cold is unknown during the warmer months in the Southern Hemisphere (see p. 390).

(*d*) Humidity.

It is now necessary to refer briefly to the question of relative humidity discussed in the preceding chapter (see p. 397).

This term is an expression of the drying-power of the air, the power being determined by the temperature of the

air, and the amount of moisture present. It is clear that the actual amount of moisture is not the same thing as the relative humidity ; for instance, at a low temperature there may be high relative humidity and comparatively little moisture, because the drying-power of the air is slight ; while at a higher temperature the relative humidity may be less, although the actual amount of moisture may be increased. With high relative humidity and high air-temperature the air is oppressive, and loss of heat diminished ; with high relative humidity and low air-temperature the air is clammy, and produces a sensation of searching chill, owing to conduction of heat from the surface to the surrounding moisture; with low relative humidity and high air-temperature the drying-power of the air is excessive, and an irritant effect on the skin and lungs may ensue, causing a hard dry cough and other disagreeable effects ; with low relative humidity and low air-temperature the effects are exhilarating and pleasant, providing always that winds are absent or only moderate in force.

The air in districts where the rainfall is heavy tends to check evaporation of moisture from the skin. As already explained, the atmosphere can only hold a definite quantity of moisture at a definite temperature, and when this limit is reached the air is said to be saturated. It is evident that the nearer the point of saturation is approached the less moisture the air will be able to hold, and the more completely will evaporation from the skin be checked. As evaporation is one of the principal means by which heat is withdrawn from the body, these facts furnish an explanation of the intense discomfort and malaise produced by great heat combined with moisture. It is under these circumstances that heat apoplexy is likely to occur. A moist atmosphere not only checks evaporation, but radiation as well, and clouds, which are only condensed moisture, have the same result. It is well known that dew is not deposited when the sky is overcast, as radiation from the earth is checked under these circumstances (see p. 385). The danger and discomfort of damp and cloudy weather are well known

to residents in the tropics and in the plains of India. Although not in accordance with popular belief, experience leaves no room for doubt that to consider the presence of clouds as a protection against heat-stroke is a dangerous fallacy. In cold weather the effects are not the same as above. Water conducts heat better than air, so that on a cold, damp day the sensation of chill may be greater than on a cold dry day, although on the latter occasion the temperature may be actually lower. The apparent contradiction was noted by the Japanese at the Battle of Hei-Kou-Tai, January, 1905.

A dry atmosphere has a result directly contrary to the above. Evaporation is greatly increased, and the higher the temperature the greater the drying effect. Under the influence of dry air the skin becomes hard and brittle, and the irritation produced on the lungs by loss of moisture is shown by an irritating cough. It has already been explained that evaporation is accompanied by loss of sensible heat, so that the particularly chilling effect of a dry wind can now be readily understood. Under the influence of the dry and cold air which is brought to our coasts in the easterly winds, the bloodvessels of the skin contract and perspiration is checked; any perspiration, however, which is on the surface is quickly taken up by the atmosphere which, in virtue of its lack of moisture, has considerable evaporating power even at a comparatively low temperature. Cracks easily occur in the dry cuticle; the surface of the body becomes chilled under the combined influence of evaporation and contracted bloodvessels; and the train of discomfort follows which is such a familiar accompaniment of the east winds. When the temperature of the air is raised, these effects are proportionately modified. Although far more easily tolerated than a moist and heated atmosphere, the effect of dry air at a high temperature, in encouraging rapid evaporation from skin and lungs, is, as stated above, nevertheless sufficiently irritating. The hot and dry winds which blow over the plains of Bengal, before the rains, are well known for the general discomfort which accompanies them.

Egypt is an excellent example of an excessively dry climate, and it is interesting to observe certain conditions which obtain in that rainless country.

Absence of vegetation—the result of absence of rain—leaves the ground exposed to the full force of the rays of the sun, the heat of the latter being rapidly taken up by the sandy and arid soil, while the cloudless atmosphere allows radiation from the earth to proceed during the night at a rate which produces, by contrast, most trying changes of temperature. Intense heat by day, bitter cold by night, an arid soil, scanty vegetation, and blinding dust-storms, are among the results of a rainless climate. These disadvantages may not appeal to the tourist who sees the Nile at the best season of the year, and who carries with him the usual resources of civilization ; but the soldier on service, being devoid of the ordinary comforts of life, is a better judge of the effects of the climate untempered by artificial means. It may be well to explain that the above statements are not intended to bear a universal application with regard to Egypt, as the conditions which have been mentioned are naturally modified according to season and locality.

An attempt at detailed discussion of all climatic conditions which influence health would, besides leading into the region of scientific uncertainties, be altogether beyond the scope of this book. Enough has possibly been said, however, to indicate certain general principles which may be useful in arriving at conclusions concerning the climatic influences of some, at least, of our foreign stations.

CHAPTER XXI

GEOLOGY

It would be impossible to discuss at present all the geological problems connected with health, and it is therefore only intended to suggest a line of inquiry which appears to have an immediately practical value, and which, in view of recent military developments, in the shape of the Territorial Army, is likely to assume an importance which, up to the present, it has not possessed.

Rock is that compact substance which is found beneath the soil and subsoil; while the two latter consist of portions of rocks disintegrated by the united influences of chemical, vital, and physical causes mixed with organic matter and serving as a storehouse of nutriment for the vegetable world.

'Substances of uniform composition which go to form rocks are called minerals.'* It must be remembered that minerals are definite chemical compounds, and that while rocks always consist of one or more minerals, all minerals do not form rocks, or, to use an ordinary expression, some minerals are rock-forming and others are not.

Minerals may be classified as follows:

1. *Elements*, such as carbon or sulphur. The first named is well known to occur in the form of diamonds.

2. *Acid Oxides*.—These contain the non-metallic element silicon, united with oxygen. Silica—which consists of silicon and oxygen—is the form in which they occur. It has been calculated that Silica forms about a third of the crust of

* Bird's 'Elementary Geology,' p. 24.

the earth. It is found in granite, quartz, rock-crystal, flint, and more rarely in the form of precious stones, such as the cairngorm, agate, jasper, amethyst, etc.

3. *Basic Oxides.*—These may be regarded as metals united with oxygen. Samples are found in the iron oxides magnetite and hæmatite ; also in alumina in various forms—notably in sapphire which is alumina, transparent and coloured blue.

4. *Salts.*—Examples are found in carbonate of lime, sulphate of lime, chloride of sodium, and double silicates of aluminium, and some other metal, usually potassium or sodium. The silicates are known as felspars, and are found in granite.

Having learned something of the actual substances which go to form rocks, we may next consider the various forms under which they are known to occur. The forms in question can be conveniently grouped under three principal classes.

1. The first class is known as the aqueous or stratified —the latter designation, which is the best of the two, being suggested by the fact that the rocks are found in layers ; the second is the igneous ; the third is the metamorphic. The aqueous rocks—(*a*) have either been deposited in water as a clayey or sandy sediment ; (*b*) have been chemically formed in the shape of carbonate of lime, sulphate of lime, sodium chlorides, flint, etc., (*c*) have been formed from animals or vegetables, and occur either as limestone, corals, shells, etc. ; and in the case of vegetable remains, as peat, coal, jet, or plumbago.

2. The igneous rocks, which were originally in a molten condition, are divided into volcanic and plutonic. The former, the least important from the present point of view, have cooled on the surface, while the latter have cooled and solidified within the substance of the earth, and commonly occur as granite and greenstone.

3. The last class—*i.e.*, the metamorphic—consists of rocks ' in which molecular changes have caused the formation of new compounds, and have rendered the mass more or less crystalline ' (Bird). The most important repre-

sentatives of this grouping are slate, marble, quartzite, and sometimes granite.

Rocks are also classified according to their respective ages, and, although the order is not constant, the oldest, as might be expected, are found at the greatest depths. It is a circumstance of great practical interest that representatives of all the principal groupings are to be found in the British Isles, and as there are wide differences in their bearings on health, the importance of choice in connection with camping-grounds and other military locations becomes evident.

Generally speaking, the most recently-formed rocks are found in the south-east districts of England, the older rocks lying to the west and to the north.

The explanation of certain terms may here be useful:

Each layer of rock is called a 'stratum'; a succession of strata resembling each other is called a 'series' or else a 'formation.' A large division, often containing several series, is called a 'system.' Thus we speak of the Silurian, Cambrian, Devonian, or other 'system.' The place where a bed of rock comes to the surface is called the 'outcrop'; the direction in which the bed slopes is called the 'dip'; and a line at right angles to the 'dip' is called the 'strike.' The hollows of an undulating bed are called 'synclinals,' and the ridges 'anticlinals.' The fine mud and silt deposited by a river which has overflowed its banks is called 'alluvium' (see p. 426). A detached portion of an upper bed lying on a lower bed is called an 'outlier'; a portion of a bed exposed by the removal of the beds above it is called an 'inlier.'

Clay with a large proportion of sand is 'fireclay'; with less sand and more moisture it is 'fuller's earth'; if mixed with calcareous matter, it is a 'marl'; while approximately equal parts of sand and clay constitute a 'loam.'

A 'fault' is an enormous split in the rocks, running sometimes for miles through the country, and allowing the strata on one side of it to slip down to a lower level than those on the other side. The former side is called the 'downthrow,' and the latter the 'upthrow.' The slope of the 'fault' is called the 'hade.' Thus, for example, a 'fault' is said to

'hade' to the north-west, or in any other direction. I recently heard the question raised as to whether the burial of a collection of manure from cavalry stables might contaminate a deep well by means of a possible 'fault' in the neighbourhood.

A broad classification of rocks, according to age, is found in the following groups: Cainozoic, or Tertiary; Mesozoic, or Secondary; Palæozoic, or Primary, the last named being the oldest. Each group is in turn divided into the systems

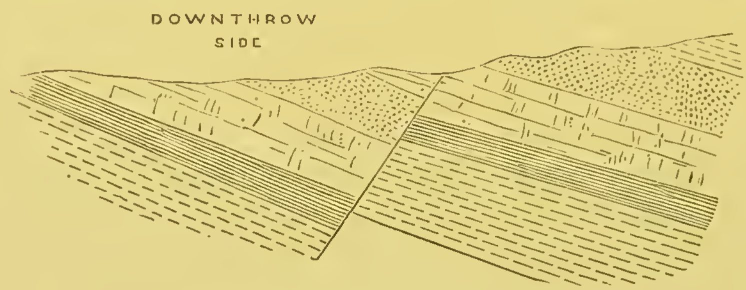


FIG. 50.—A FAULT.*

shown on the following table, and it must be observed that the Cainozoic or Tertiary group should not be confounded with the Tertiary *system*.

Cainozoic	Post-tertiary, pleistocene, or quarternary.	
	Tertiary proper.	
Mesozoic	Cretaceous.	
	Jurassic	Oolite.
		Lias.
	Triassic.	
Palæozoic	Permian.	
	Carboniferous.	
	Devonian.	
	Silurian.	
	Cambrian.	
	Archæan.	

As seen above, the most recent system is the Post-tertiary. Examples of it are found along the east coast as far as Bridlington, in the low-lying parts of Lancashire and Cheshire, in Derbyshire, North Wales, and in the Lowlands and valleys of Scotland.

* Bird's 'Elementary Geology' (Longmans, Green and Co.).

Its origin is interesting. The intense cold of the first glacial period resulted in the formation of vast glaciers which, by their grinding action, converted the surface of the earth into sand, clay, and gravel. The land next gradually sank beneath the sea, and detached portions of the melting ice carried with them huge blocks of stone, chalk, and granite, all of which latter became mixed with the sand, gravel, and the tough clay. Gradually the land rose again, and a second glacial epoch occurred, until, finally, the ice melted, and the country to some extent assumed its present appearance. It is plain from the above that representatives of this system must vary greatly among themselves.

A very large number of shallow wells are sunk in the patches of sand and gravel, and must be looked on with suspicion; springs, likewise, are common at the edges of the patches, but the yield is frequently uncertain; and the neighbourhood of farms and villages in a fairly thickly populated region renders great care necessary in selecting water from these sources.

The water, as might be expected, varies considerably in its chemical composition. The clay, commonly spoken of as 'boulder clay,' sometimes attains a thickness of 150 feet; the water is very hard, and occasionally has an odour of sulphuretted hydrogen.

Although the clay is not absolutely impervious, the water takes some time to sink through it, and the soil is therefore damp and cold.

The system next on the list is the Tertiary, and this, in turn, consists of the following divisions, beginning with the most recent:

1. Pliocene.
2. Miocene.
3. Oligocene.
4. Eocene.

The Pliocene is represented by the sands and shells, commonly called crag, found in East Anglia between Cromer and Felixstowe. The water contains an excess of chlorides,

and sometimes iron. It is, therefore, not well suited for either drinking or washing purposes. The rocks being near the sea, the excess of chlorides is easily accounted for.

The Miocene is believed not to be represented in England, and the Oligocene and Eocene can be considered together.

From a military point of view the two latter form an important system. The higher strata are represented by the Hempstead, Bembridge, Osborne, and Headon beds in the Isle of Wight.

FIG. 51.—COUNTRY NEAR ALDERSHOT (SANDY SOIL AND HEATHER).
Photograph by Gale and Polden, Aldershot.

They are mostly sands, but also contain limestones, marls, and clays. Next come the Bagshot sands: these are found in the neighbourhood of Frimley, Bagshot, Chobham, Aldershot, and Sandhurst; they form the Frimley and Chobham ridges and the moorland district of Blackdown. The region which they comprise is widely covered with heather and pine; the soil is porous, and dries very rapidly after rain; and the water is beautifully soft, though it sometimes contains iron. The vegetation of the district prevents

the rapid changes of temperature which are usually associated with sandy soils, and although it must be admitted that sand is not well adapted to deal with organic refuse, the conditions as a whole are leading factors in maintaining a high standard of physical efficiency amongst the troops of the local command.

Beneath the sand in both the London and Hampshire basins is found the London clay; the latter is about 400 feet deep in some parts; it is very tenacious, and contains clayey,

FIG. 52.—SALISBURY PLAIN (CHALKY SOIL AND GRASS).
Photograph by Gale and Polden, Aldershot.

calcareous nodules which are used for cement, sulphate of lime, and pyrites. The water is very hard; and, besides being impervious, and therefore damp and cold, the soil is ill suited to deal with organic matter; camp refuse, consequently, cannot easily be disposed of, and trench latrines should naturally be avoided.

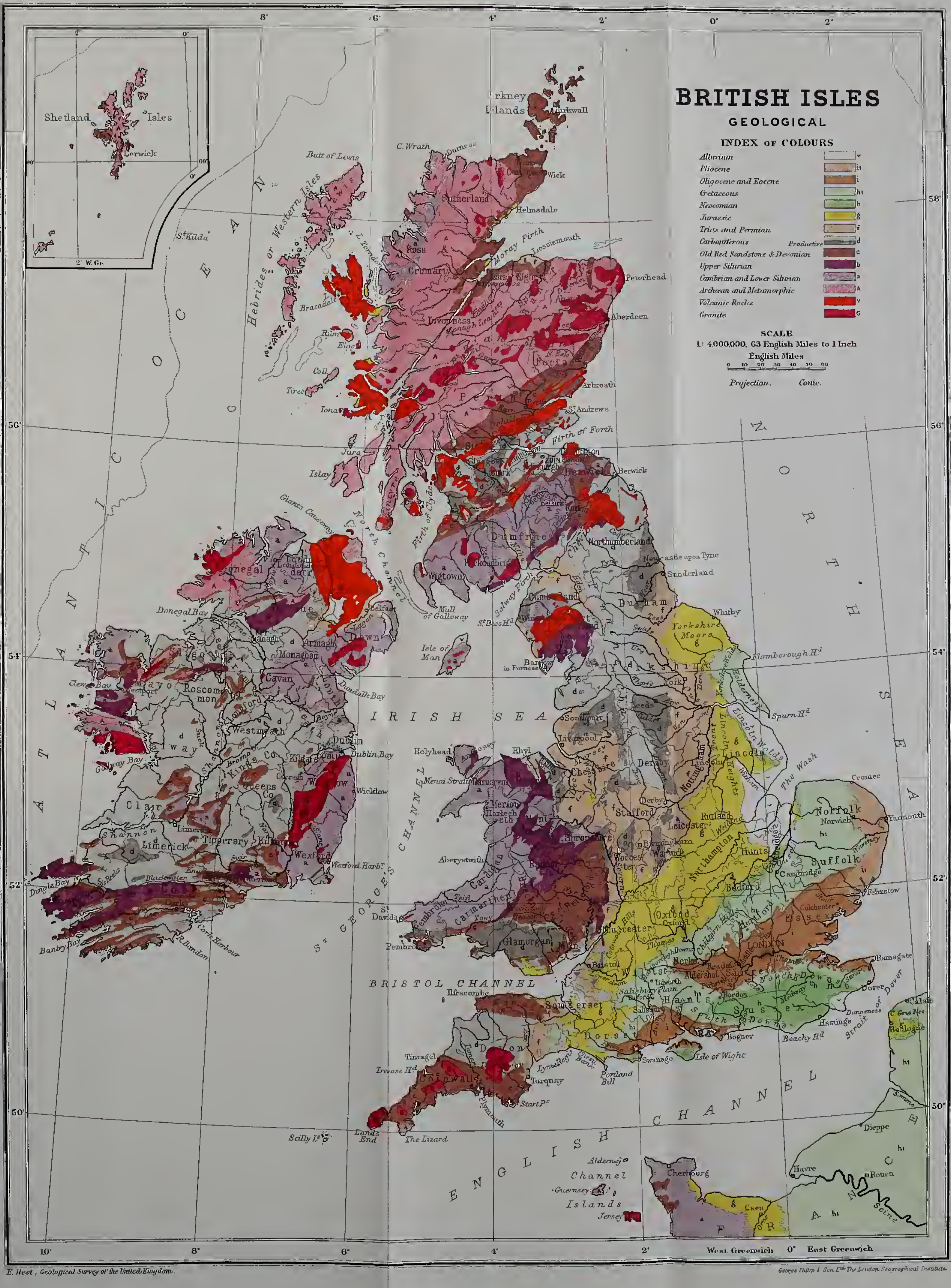
Clayey soils are cold and damp on account of the presence of water, which remains on or near the surface, it being a well-known fact that the specific heat of water is relatively high,

meaning that water requires a relatively large amount of heat to raise its temperature (see pp. 403 and 404).

The other formations are not of any particular importance: they consist of the Oldhaven, Woolwich, and Reading beds, and of the Thanet sands. The former lie at the base of the London clay, and the latter, which have only a limited outcrop, lie immediately above the next group to be considered.

The succeeding group is the Secondary. It consists of the following systems—viz., the Cretaceous, the Jurassic, and Triassic. The Cretaceous consists of an upper and lower division, the first comprising the chalk, upper greensand, and gault, and the latter, or Neocomian (from *Neocomium*, Latin for Neufchâtel, where the beds in question are well developed), comprising the lower greensand, the Weald clay, and the Hastings sands.

As shown above, the highest formation is the chalk, and from a military aspect it is one of great importance. It stretches across the country in a broad sheet from the north-east to the south-west ; it forms the Lincolnshire and Yorkshire Wolds, Chiltern Hills, Marlborough Downs, and North and South Downs. It dips under the London district and under part of Hampshire, forming the London and Hampshire basins. Between the two basins it bends upwards in a broad anticlinal, the eastern portion of which forms Salisbury Plain, while the western portion has been planed off by the sea, and the beds below exposed, thus furnishing an excellent example of what is known as a plain of marine denudation. The ridges where the chalk ends at the edges of the plain form the North and South Downs, together with the various spurs known by other names. These hills constitute a most important source of water-supply, as they consist of a chalk outcrop into which rain-water can sink, and the water passing beneath the clay in the London basin can be tapped by means of artesian borings. The space between the Downs forms part of the region known as the Weald of Kent, the lowest of the exposed beds—namely, the Hastings sands—rising in a ridge midway between the north and south boundaries of the plain.



E. Best, Geological Survey of the United Kingdom.

George Philip & Son Ltd The London Geographical Institute.

(From Bird's Geology, by permission of Longmans, Green & Co)

Surrounding the Hastings sands is the Weald clay, and above the Weald clay is the lower greensand. Separating the upper from the lower greensand is a bluish, marly clay known as the Gault, and above the upper greensand is the chalk.

Some of the above require more detailed mention. The chalk is probably the most important water-bearing formation in England, the water being divided into two classes, the calcareous and the alkaline: the former is hard, but the hardness is chiefly temporary; the latter is soft, and is found where the chalk lies buried deep beneath the London clay. In East Yorks, Norfolk, and Suffolk, the water sometimes contains so much ferrous carbonate as to be unfit for

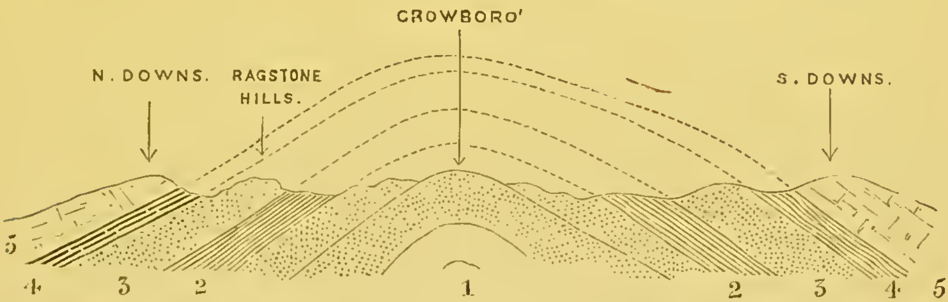


FIG. 53.—THE WEALD: SECTION FROM THE ENGLISH CHANNEL TO THE THAMES.*

1, Hastings Beds; 2, Weald Clay; 3, Lower Greensand; 4, Gault and Upper Greensand; 5, Chalk.

use; these waters are yellowish when drawn, but become brown on exposure to the air. Chalk is not well suited for the purification of organic matter, and being full of fissures and large spaces, known as swallow-holes, polluting material may travel considerable distances. In digging latrine trenches for camps great care should be exercised to avoid going deeper than the subsoil, so as not to disturb the subjacent rock. There is an excellent system of sewage purification at Tidworth; the sewage is distributed over the surface in branching channels, but the depth of subsoil insures safety against pollution of the chalk. An objectionable feature of chalk soils is the frequent formation of tenacious or slippery mud, which is very fatiguing to marching troops. In spite

* Bird's 'Elementary Geology' (Longmans, Green and Co.).

of its drawbacks, chalk is generally a healthy soil; vegetation, in the form of grass, is plentiful, and the water, though hard, is generally pure.

The upper greensand and lower greensand are both water-bearing formations. In the case of the upper greensand the quality varies greatly; it is usually calcareous, and may contain iron. The water from the lower greensand is tapped by numerous artesian borings, but there are many wells near Sevenoaks, Dorking, and Farnham. The supply is pure, but may contain iron. The Royal Commission (1869) reported favourably on the supply from this source. The Gault which lies between the above is very important; being impervious, it holds up the water, and its outcrop along the downs is marked by springs, which, in turn, have resulted in the birth of many villages in this region.

The Weald clay is a flat, water-logged district, which should be avoided for camping purposes. A type of Weald country can be seen between Reigate and Ashford. The Hastings sands are a distinct contrast to the above, being hilly and diversified. They consist of sand, sandstones, and mottled clay. The district is healthy; the water, though sometimes of a character like that beneath the London clay, and therefore soft and alkaline, is often found to contain considerable quantities of iron.

The next system—viz., the Jurassic—is divided in England into the Oolite and the Lias. These can conveniently be considered together; reference to the geological map will show them crossing England as a broad band, which stretches from Whitby to Lyme Regis.

The Lias mainly consists of stiff, damp clay with some limestone. The Oolite consists of a succession of clays and limestones; this alternation has naturally a considerable influence on water-supply, as the limestone forms a series of pervious outcrops lying between the impervious clays. Springs, as might be expected from the above, are numerous in the Oolite district; among others of importance are the seven springs which form the source of the Thames in the Cotswold Hills.

It is a highly important fact that, owing to fissures in the limestone, polluting material may be carried for considerable distances. The water of both Oolite and Lias beds is hard, but the hardness is generally removable. For camping purposes there is not much choice between the two regions, except that the Oolite as a rule lends itself to arable, and the Lias to pasture, land. The various series need not be discussed separately.

The last system in the Mesozoic group is the Triassic. It consists in England of two divisions—the upper, or Keuper, and the lower, or Bunter. For present purposes these divisions can be considered together.

This system is seen as an irregular strip of land reaching from the Tees to Devonshire; it spreads out in the Midlands, and occupies considerable portions of Staffordshire, Cheshire, and East Lancashire. It consists in great part of coloured sandstones, marls, limestone, and beds of salt and gypsum. It is believed in parts to represent a dried-up sea, from which, as the water evaporated, enormous quantities of salt were deposited. A great deal of water is found in this district; hardness is excessive, and being largely due to sulphate of lime, it cannot be removed by boiling.

While inspecting the proposed site of a Territorial camp near Tewkesbury in the summer of 1908, I was told that most of the wells in the neighbourhood were brackish, and arrangements were made to take advantage of the municipal supply.

There is a good deal of pasture-land in this district. The soil, except as regards the Lias clays, is fairly dry, and the water, in spite of its defects, is pure, but not well suited for washing purposes.*

Birmingham suffered greatly from the nature of its water-supply in past years, and the waste in soap alone was enormous. The present supply, which is brought from Wales, is unsurpassed in excellence.

The oldest group is the primary, or Palæozoic. It con-

* *Vide* Royal Commission on Water-Supplies.

sists of the six following systems, the first named being the most recent: (1) Permian; (2) Carboniferous; (3) Devonian; (4) Silurian ; (5) Cambrian ; (6) Archæan.

The same general remarks apply to the Permian as to the preceding system, with which it was formerly classed under the heading of New Red Sandstone. It is conveniently divided into two series, an upper, consisting mostly of magnesian limestone, and a lower, of sandstone and red marls. It is found on either side of the Pennine range, and in Worcestershire and Warwickshire. It is a healthy soil, but the water is often very hard, owing to the magnesian limestone from which it is obtained.

The Carboniferous system mainly comprises carboniferous limestone, specimens of which are to be found in and about Matlock and Buxton, and in the Mendip Hills ; it constitutes a large portion of the Pennine range, and is common in the dales of Yorkshire. It also contains large quantities of a coarse sandstone, known as Millstone grit ; this seems to be the waste of a region of granite, originating probably in Scandinavia, and it is thought that in a remote period it was brought down by great rivers from the north. It is interesting to observe that the carboniferous limestone, known also as mountain limestone, tends to disappear towards the north, and to be gradually overspread with a variety of detritus. The explanation seems to be found in the fact that in the south the formations remained open to the sea, in which they originated, being, in fact, mostly composed of coraline deposit and marine shells generally. In the north they became gradually covered over with the waste carried by rivers from other regions. In this waste, forests flourished, and these, in course of time, becoming submerged as the land sank, laid the foundation of existing coal-measures. It will be clear from what has been stated that the soil of the Carboniferous system varies greatly ; it is divided into two groups, the coal-bearing and non-coal-bearing, the latter, as might be expected, being found in the south. A large proportion of the Millstone grit region is represented by the moors of Yorkshire—hills covered with peat and heather, and

commonly devoted to grouse-breeding. In the coal-measures the water is often hard; it contains a great deal of saline matter. In the Millstone grit region the quality is variable, but is generally soft. When collected from peaty soil, as is frequently the case in regard to moorland water, it is apt to have a strongly solvent action on lead. In the carboniferous limestone formation the water commonly issues from numerous fissures in the rocks; although generally pure, the supply is too hard for domestic use. On the whole, the Carboniferous system can be considered a healthy one.

The next system, the Devonian, is widely spread throughout the British Isles. It consists of two divisions, the old red sandstone and the Devonian proper. An important part of the former extends from Shropshire through Wales into North Devon. It is believed to owe its origin to the volcanic disturbances which took place during the Silurian era; some parts of the land were depressed and some elevated; and basins were thus formed, which became receptacles for the detritus of the surrounding country. The old red sandstone is therefore far from being of a uniform composition, consisting, as it does for the most part, of enormous beds containing samples of nearly all the older formations. The red colour, which is commonly observed, is caused by the presence of iron. The water is moderately soft, and the soil is generally healthy.

The Devonian division is very different from the above, and consists of shales, sandstone, and coraline limestone. It is found in Devon and Cornwall, and is of marine origin. The water is soft, and the soil healthy. The three oldest systems do not call for individual discussion; they consist, in order of age, of the Archæan, the Cambrian, and the Silurian systems. The rocks are hard and impervious, and though little water is obtained from the rocks themselves, enormous quantities run from their surfaces, and form excellent supplies for distant cities. The districts where these rocks are found are among the healthiest in the United Kingdom.

A very fair idea of the nature of soils may be gathered from the appearance of rivers. In the case of stiff, impervious soils the channels are narrow and the banks steep; in the case of looser soils the banks are shelving and the channels broad and shallow. The difference is due to the fact that the first-named soils have withstood the disintegrating influences to which they are exposed. Respective examples may be found in the Severn as it flows through part of the Midlands, and in the Dee in its course through Aberdeenshire and Kincardineshire.

In conclusion, it should be stated that sandy, peaty, and clayey soils are not well adapted to deal with organic refuse; that peaty water acts energetically on lead, and therefore that the plumbo-solvency of such water should invariably be tested (I lately found high plumbo-solvency in a sample of water obtained from a stream at Willsworthy, an isolated spot near the south-western edge of Dartmoor. The source in question was designed to supply a projected musketry camp); that, apart from any other reason, the impermeable nature of stiff clay renders the soil highly objectionable for camping purposes—in fact, after heavy rain the camps are often under water; that, when possible, permeable soils should be selected for camps, either gravel or loam being among the best; that alluvial soils are damp and difficult to drain—they often contain large quantities of decaying matter, and the water is in consequence apt to be very impure (see p. 415).

The following table may be useful in summarizing the geological groups which have been mentioned:

Cainozoic	Post-tertiary, pleistocene, or quarternary	Sands and gravels. Boulder clay.
	Tertiary proper	Pliocene (East Anglian crags). Miocene (scarcely represented in England). Oligocene (sands at Alum Bay, Osborne, Bembridge, Hempstead, Bagshot). Eocene (Blackdown, London clay, Reading, Woolwich, and Oldhaven beds, Thanet sands).

- Mesozoic
  - Cretaceous
    - Upper Division
      - Chalk.
      - Upper greensand.
      - Gault.
    - Lower Division, or Neocomian
      - Lower greensand.
      - Weald clay.
      - Hastings sands.
  - Jurassic
    - Oolite.
    - Lias.
  - Triassic
    - Keuper.
    - Bunter.
- Palæozoic
  - Permian
    - Magnesian limestone.
    - Red sandstone, red marls.
  - Carboniferous
    - Coal-measures.
    - Millstone grit.
    - Mountain limestone.
  - Devonian
    - Old red sandstone.
    - Devonian.
  - Silurian.
  - Cambrian.
  - Archæan.

CHAPTER XXII

ALCOHOL

BEFORE attempting to discuss the question of alcohol as it affects military service, it may be well to consider briefly what the drug actually is, how it is prepared for trade purposes, and its general effects on the human organism. Alcohol, or, to be more exact, vinic or ethylic alcohol, is a combination of carbon, hydrogen, and oxygen in the following proportions: C_2H_6O—viz., 2 parts of carbon, 6 of hydrogen, and 1 of oxygen. In the language of organic chemistry, it is the hydroxide of the hydro-carbon radical C_2H_5, and may be represented by the formula $C_2H_5(OH)$. It may be regarded as ethane, or C_2H_6, in which one atom of hydrogen has been replaced by hydroxyl, or OH. Of the two formulæ, $C_2H_5(OH)$ is the more scientific representation of the drug; it may possibly be considered at the same time to have the corresponding disadvantage of being more complicated, but a few elementary facts, once mastered, make the whole subject more comprehensible, and therefore more interesting.

For trade purposes alcohol is obtained by the action of yeast, and other ferments, upon sugar. The change may be represented by the following equation:

$$\underset{\text{Sugar.}}{C_6H_{12}O_6} = \underset{\text{Ethylic Alcohol.}}{2C_2H_6O} + \underset{\text{Carbonic Acid.}}{2CO_2}.$$

It may seem impossible that the mere alteration of numbers can convert a substance like sugar into another of an entirely

different nature, but the fact is only one of many which are found in the region of chemical science.

In the case of wine the ferment is found on the skin of the grapes; when the grapes are crushed, the ferment has access to the sugar contained in the fruit, and the above action rapidly takes place. If the action is allowed to continue until the sugar is used up, a dry wine results; while, should the action be incomplete as regards sugar, the unfermented portion of the latter will cause the production of a sweet wine.

Spirits are made by heating any alcoholic liquid until alcohol, which forms the lightest part, is driven off in the form of vapour, and the latter is then condensed by passing it through a coil kept cool by water.

The preparation of alcohol which concerns us most at present is that connected with brewing. The principle of the process is roughly as follows: The barley-grains consist largely of insoluble starch; as soon as the grain begins to grow, the starch is converted into sugar by a ferment in the grain known as 'diastase,' and the sugar produced serves to nourish the grain until the latter is old enough to obtain by its rootlets the necessary nutrition from the soil. The conversion of starch into sugar is another example of a new body being formed by an alteration in numbers:

$$\underset{\text{Starch.}}{2C_6H_{10}O_5} + \underset{\text{Water.}}{2H_2O} = \underset{\text{Sugar.}}{2C_6H_{12}O_6}.$$

It should be explained here that the sugar found in the grape and in fruit generally is known as glucose, and that its formula is $C_6H_{12}O_6$; while the sugar formed by the action of diastase on starch is maltose, and its formula is $C_{12}H_{24}O_{12}$, or, more correctly, $C_{12}H_{22}O_{11}(OH)$. It will be seen that the relative numbers of atoms are identical in the two forms.

The natural conversion of starch into sugar is taken advantage of by the brewer, who allows the barley-grains to germinate in the malting-house. Of course, it would not do to allow the process to continue indefinitely, or all the sugar

formed would be used up by the sprouting grains, so the process of development is checked by heating the grains in a kiln, but not to such an extent as to damage the ferment. The sprouting grains are then broken up and placed in the mash-tub with water, and the ferment continuing to act, a liquor known as the ‘ sweet wort ’ is produced. The ‘ sweet wort ’ is next boiled, hops being added to clarify and give the bitter and pleasant taste which is characteristic of good beer ; lastly, by the action of yeast, the sugar is converted into alcohol, and the process is complete. Broadly speaking, the changes which occur can be divided into two distinct stages : First, the conversion of the starch of the barley-grain into sugar by means of the diastase ; second, the conversion of the sugar into alcohol by means of the yeast. Such is the process of brewing when it is carried out in the simplest form, but according to the minutes of evidence taken before the Departmental Committee on Beer Materials in 1896, the liquor is likely to contain many other materials besides those named. Various substitutes are used in lieu of hops, and sulphuric acid is found in beer brewed with soft waters. As hard waters containing sulphate of lime are best for brewing, an attempt is sometimes made to supply the deficiency by the more than questionable addition which has just been named ; while not so many years ago a serious outbreak of poisoning occurred as the result of the use of arsenical sugar, instead of sugar produced by the natural means just indicated. With a view to economy, the brewers, instead of following Nature’s methods, made use of sugars obtained by acting on starch or cane-sugar with sulphuric acid, and as the latter is apt to contain arsenic, the results were disastrous.

‘ The glucose used by brewers is usually “ solid.” It is manufactured on a large scale at factories in Great Britain, and a considerable quantity is also imported from America and Germany. The glucose used for confectionery, syrups, and other food purposes, is generally “ liquid,” and is almost always imported. Solid and liquid glucose alike are liable to contain arsenic derived from sulphuric or hydrochloric

acid, which are used in varying proportions (*e.g.*, from 2 to 6 per cent.) in the "conversion" process by which the glucose is manufactured from starch. In view of the circumstances of the 1900 epidemic, it is unnecessary to insist upon the high degree of arsenical contamination of glucose which may be brought about by neglect of precautions regarding the quality of the acid used. Solid glucose in several instances was ascertained to contain as much arsenic as 3 grains per pound, and even larger proportions of arsenic were estimated in a few specimens. . . .

'The "invert" sugar which is used by brewers (and sometimes also in the preparation of cider and of certain fermented "non-intoxicating" beverages) is manufactured in this country on a considerable scale by subjecting cane or beet sugar to an "inversion" process, in which sulphuric acid is added to the sugar. . . . About 3 per cent. of sulphuric acid was used for this purpose, and the "invert" sugar produced in 1900 contained large amounts of arsenic (estimated in different specimens from 1·4 to 4·3 grains per pound).'*

It is only right to state that in the United Kingdom all evidence goes to show that every reasonable care is now taken to insure the use of none but wholesome sugar, and the matter would therefore not have been referred to if it were not for the fact that at some of our foreign stations there is reason to believe that the danger still exists in a relatively acute form. It would be a sound course if the beer for use of troops were periodically examined for the presence of arsenic, at every station abroad.

There are many other forms of alcohol besides the one now in question, and it will be quite within the limits of the subject if two of the more important receive some particular attention; these are respectively hydroxides of the hydrocarbon radicals, or CH_3 and C_5H_{11}, the precise formulæ being $CH_3(OH)$ and $C_5H_{11}(OH)$. Each is formed on exactly the same principle as ethylic alcohol—that is, by the substitution

* Final Report of the Royal Commission on Arsenical Poisoning, pp. 22, 23.

of OH for one atom of hydrogen in CH_4 and in C_5H_{12} respectively.

Methyl alcohol, or $CH_3(OH)$, is commonly known as methylated spirit, and its taste can be recognized without much difficulty in inferior brands of whisky. It can be distilled from wood, and is sometimes spoken of as wood-spirit. During the Nile expedition the Arabs prepared this spirit from palm-branches, and sold it to the troops, with occasionally startling results. At Assouan I was told that it could be purchased at 1 piastre—about 2½d.—a bottle, and, when consumed as a beverage under a blazing sun, with a temperature of about 120° in the shade, it produced a form of intoxication not immediately distinguishable from certain forms of lunacy. I remember, when coming down the Nile with time-expired men in 1885, that the Arabs along the banks made a good trade in this form of refreshment, and that, in spite of every precaution on the part of the officers, the men imbibed freely. The results speedily made themselves manifest in a series of episodes of a highly interesting nature, and by the time we reached Cairo a fair number of men were in a condition uncomfortably suggestive of homicidal mania.

In the Annual Report for 1908 of the Surgeon-General United States Army, there is an interesting account of an outbreak of poisoning from methyl alcohol at Camp Keithley, Mindanao. Twenty-eight men were attacked, and eleven of this number died within forty-eight hours. The occurrence was the result of a carouse with 'Columbian spirits,' which had been mixed with milk and sugar, and consumed as punch. It was remarkable that all fatal cases appeared to go blind before death, and it was believed that in one of the cases that recovered blindness would probably ensue. The amount of liquor consumed was absolutely appalling—a fact which appears to have been due to there being no canteen in the station, and the men therefore being anxious to take full advantage of what had been thrown in their way.*

* Report of Surgeon-General United States Army for 1908, p. 98.

Amyl alcohol, or $C_5H_{11}(OH)$, can be obtained from potato starch, and is sometimes known as fusel oil. It is the leading constituent of the liquor, which is often produced in illicit stills; it is also common in cheap brands of whisky, and can be detected by the fact that it is not appreciably soluble in water, and therefore floats on the surface like an oil when water is added to the liquor. Its general effects are somewhat of the same nature as those already described in connection with methyl alcohol, but probably not quite so serious.

For present purposes the effect of alcohol can be considered as twofold:

1. Its immediate effect on the heart and the bloodvessels of the skin.
2. Its effect on the nutrition of the body.

1. Its Immediate Effect on the Heart and Bloodvessels of the Skin.

To the majority of persons the first sensations produced on partaking of alcohol are certainly far from an unpleasant nature, and may be summarized generally under the headings of well-being and warmth. The beats of the heart are increased in number and force; the bloodvessels of the skin dilate; a pleasant glow is produced; and languor and malaise are banished, or diminished for the time being. Unfortunately, these effects have led to the utterly erroneous belief that alcohol is a protection against cold and a preventative of fatigue. It is almost impossible to imagine any assumption more false, and not only false but dangerous. By increasing the contractions of the heart, alcohol causes that organ to perform work when there is no necessity for the same; in other words, it is directly productive of useless labour. If we imagine that alcohol, in addition to increasing the action of the heart-muscle, needlessly causes the rapid contraction of all the other muscles in our bodies, we can conceive how remarkable results in the direction of exhaustion would be quickly produced. The capacity for great exertion depends on the power of the heart,

and it follows that to partake of a drug which calls on the heart to do needless labour is, to say the least of it, the reverse of a common-sense proceeding. To put the matter in somewhat different words : by taking alcohol previous to exertion we help to tire by unnecessary work, in the way of contractions, that very muscle—viz., the heart—upon which the successful attainment of our object depends. Passing to another effect of alcohol, that pleasant feeling of warmth produced by wine or spirits is the direct cause of serious loss of heat by the body. The bloodvessels of the skin dilate under the influence of what has been swallowed, and in dilating so close to the surface they allow heat to pass from the animal frame into the surrounding atmosphere.

The contraction of the bloodvessels of the skin under the influence of cold, by checking the loss of heat from the surface of the body, is Nature's protection to internal organs. It is much to be regretted that these facts are not more generally known; were it so, the 'tots' of rum served out on a cold night on service would be less frequent, or, better still, would absolutely cease.

The effect of alcohol in this direction is thoroughly borne out by the practical experience of those whose work is carried out in cold climates :

'In Canada the men who are called lumberers live in camps far away from civilization. During the whole winter they fell the trees, and these are dragged along the snow to the river, where they are made up into rafts. These men will not have any alcohol near them in the winter. On one occasion a man conveyed a cask of whisky into one of their camps, and the first thing they did was to take an axe and knock a hole in the cask, so that the whole of the whisky ran out. The reason of this was, they did not dare to have the whisky there, for if it was there, they felt quite sure they would drink it, and if they drank it, they were likely to die.

'A party of engineers were surveying in the Sierra Nevada. They camped at a great height above the sea-level, where the air was very cold, and they were miserable. Some of them

drank a little whisky, and felt less uncomfortable; some of them drank a lot of whisky, and went to bed feeling very jolly and comfortable indeed. But in the morning the men who had not taken any whisky got up all right; those who had taken a little whisky got up feeling very unhappy; the men who had taken a lot of whisky did not get up at all: they were simply frozen to death. They had warmed the surface of their bodies at the expense of their internal organs. Some time ago Sir Joseph Fayrer was out deer-stalking in the North of Scotland. He offered his flask to the keeper. The keeper said: "No, Sir Joseph, I will not take any to-day; it is too cold." And yet, if he had drunk the whisky, he would have, for the time being, been very much warmer than before.

'So that alcohol tends to act as an antipyretic by dilating the vessels of the skin, and so allowing a loss of heat.' *

2. Its Effect on the Nutrition of the Body.

Alcohol has an affinity for oxygen, and it has been stated that it appropriates some part of the supply of the above which should combine with the food, and thus furnish the heat necessary for the maintenance of the body temperature, and for the energy productive of the various processes which taken together constitute life (Horsley). It has already been pointed out in the chapter on Food that the incomplete burning of the fuel—or, in other words, of our daily food—results in the production of an excess of fat and of substances of a generally deleterious nature, notably uric acid (see p. 292).

The effect of these bodies is to bring about serious changes in the liver, kidneys, and bloodvessels, and a whole train of diseases, among which gout, Bright's disease of the kidneys, atheroma, cirrhosis of the liver, and possibly aneurism, occupy prominent places.

It is a commonplace of everyday knowledge that a heavy drinker is often a fat, gouty, short-winded, and generally unwholesome individual, a walking compendium of disordered

* 'The Action of Medicines,' by Sir. T. Lauder Brunton.

functions, and, of course, seriously handicapped in the fierce struggle for life.

It is sometimes affirmed by temperance enthusiasts that alcohol is not a food. This statement is an error. The work of Frey, Joteyko, and many others, leaves no room for doubt on this point. At the same time, the man who endeavoured to obtain energy from this source would probably find his sphere of utility seriously limited by the early advent of hopeless intoxication.

In the case of severe physical exertion, it is certain that the best results are obtained without alcohol. 'For example, in 1892 the Great Western Railway decided to change the gauge along 200 miles of their system. It was needful to complete this work in two days. Every possible preparation was made, and 5,000 skilled workmen were collected for the job, the huge task being accomplished in thirty-one hours. The managers, owing to previous experience, decided that not a drop of liquor should be permitted along the line of work, and they supplied instead good oatmeal and water, about 10 tons of oatmeal being used.' *

It is an interesting fact, although not one of much practical value, that, as shown by Stoklasa, Landsberg, and Reach, alcohol is actually formed in the body, but, for reasons not clearly understood, it does not under these circumstances produce results with which we find it to be otherwise associated. An important point in connection with alcohol is its power, or otherwise, to protect the organism against the attacks of infective disease; and here we are on surer ground, as the researches of many workers in this direction, particularly Professor Tay Laïtenan, of Helsingfors University, Finland, have produced strong evidence that the drug materially lowers the protective power which we naturally possess—that is to say, alcohol actually destroys or weakens the barrier which Nature has established for our benefit.

It is well known that many diseases, notably pneumonia and tuberculosis, are seriously influenced by alcohol; and statistics from undeniable sources leave no manner of doubt

* 'Alcohol and the Human Body,' by Horsley and Sturge.

as to the frightful results of over-indulgence in the drug, as shown by the bills of sickness and mortality.

The good results of total abstinence from spirits is not a mere matter of theory, for in the Army Medical Report of 1884, Appendix II., p. 395, we find, in reference to the Suakim Expeditionary Force, according to Surgeon-Major Reid, Coldstream Guards, that 'no spirituous liquors have been used during this campaign. I am of opinion that their absence has largely contributed to the efficiency of the troops during the arduous duties performed by them.' In the United States Navy there is no grog ration, but the experience of the Spanish-American War certainly does not raise any suspicion of failure in efficiency.

There is no intention here either to attempt to prove the inutility of alcohol, or to champion what is generally known as the temperance cause. The latter is well represented in the army by that admirable institution, the Army Temperance Association, but the good which has undoubtedly been done by this means cannot be discussed at present.

Alcohol certainly has its good side, distinct from its administration in actual sickness. Like many other powerful instruments for good or evil, its properties must be understood before desirable results can be expected from its use. What these results are may be gauged from its effects when taken after undergoing severe mental or physical fatigue. Under these conditions the action of the heart is depressed, the blood circulates languidly, and in consequence digestion and assimilation are imperfectly performed.

It is not uncommon at the close of a forced march on service for men to become so exhausted as to be quite unable to consume the food which is essential for their efficiency. The vital processes, for want of a better term, are depressed as a consequence of the enfeebled action of the heart, and the healthy desire for food is absent—in fact, the stomach is in no condition for the reception of nutriment. Alcohol administered at this time is invaluable, as by stimulating the heart it causes an increased flow of blood through the vessels, and thus gives to the stomach the stimulus necessary

for the healthy digestion of food. This, of course, is quite distinct from the local stimulating action that it has on the mucous membrane of the organ. It should be given in reasonable dilution, and, if possible, immediately before food. If in an effervescing form, such as brandy-and-soda or whisky-and-soda, so much the better. Luxuries of this sort are not, however, usually obtainable in the field, and the alcohol is commonly issued in the form of rum. Spirit is certainly the most suitable form for the administration of the drug, as the effect on the heart is comparatively rapid. If too great an interval is allowed between the consumption of alcohol and that of food, the good effect is lost, and any appetite that may have existed is abolished. Alcohol is also of great value in helping exhausted men to make a severe but not sustained effort, such, for instance, as the last mile or so of a forced march. In the case of prolonged exertion the drug would be worse than useless.

A tired man has commonly a reserve fund of energy which can be utilized by appropriate means, and without doubt the judicious use of alcohol constitutes such means. In this respect alcohol may be compared to an ordinary commercial cheque, which adds nothing to the store that its owner may have in the bank, but which allows the store to be utilized when occasion requires. The administration of alcohol to a man whose energy is absolutely exhausted is equivalent to the presentation of a cheque against an exhausted account: in either case the presenter is confronted with the terse reply, 'No effects.'

'No knowledge is so useful as experience, and it is not possible for anyone who has observed intelligently the effect of a rum ration in warding off exhaustion and its results to deny the beneficial effect of the spirit. Like every other thing which contains a potency for good and evil, it has to be given with care and discretion. A spirit ration at the beginning of a march or early in the day would not only be useless, but a positive evil. Kept in reserve, as it were, to be used at the critical moment, it is undoubtedly one of the very best preventatives, not only of exhaustion, but of those diseases which seize upon all those who have fallen into a

state of exhaustion, the result of continued exertion under trying climatic conditions. . . . The men themselves, who in every way showed a determination to follow and carry out all the advice given to them, soon found out the value of rum taken at the proper time.

'Even men who had been total abstainers for years, and had no wish to change their principles or custom of life in ordinary circumstances, saw the good effect of the rum ration, and took it daily until they returned to the transport-ships, when they gave it up. One and all, they felt it had done them good, and in all probability prevented serious illness, and they took it just as they did the quinine, as a medicine. There was a strong consensus of opinion on the subject, if not, indeed, a universal agreement. Bovril, beef-tea, strong soup, and also chocolate or cocoa, had not the same reviving effect, though their value as preventatives of exhaustion were fully recognized.' *

It is a commonplace of experience that alcohol in the total absence of food is particularly prejudical. This is to some extent exemplified by the practice of opening regimental canteens before the dinner-hour. It would be well if all canteens were shut until after the dinner-hour, except for men allowed admission for the purpose of drawing the beer to be consumed at dinner in the respective rooms. At present the bar is filled before the dinner-hour with men smoking, drinking beer, and eating snacks of bread and cheese, thus destroying the appetites which they might otherwise have enjoyed.

My own experience leads me to believe in the prevalence of dyspepsia in the army. This probably is due to a variety of factors, including, naturally, defective teeth; and, in the absence of proof to the contrary, it is quite fair to number among these factors the constant habit of partaking of the principal meal of the day when the stomach is filled to repletion with recently-consumed beer.

Although statistics may not help us much, it is certain that the amount of intemperance is rapidly decreasing, and among other influences working in the above direction, probably one

* 'The Ashanti Expedition, 1895-1896,' Army Medical Report for 1895, Appendix III.

of the most important is the fact that officers take a personal part in the sports of the men, as the nature of the intercourse bred by football, cricket, and athletics is productive of a mutual good-will tending to the maintenance of sound discipline and self-respecting habits.

Generally speaking, the two principal causes for drunkenness are ignorance and absence of proper occupation. Men who enjoy rational pleasures are rarely given to drink; but rational pleasures are not likely to exist to any satisfactory extent in the absence of education, or, in other words, of knowledge.

A popular French writer, in describing the amusements of a steamship fireman with his friends, thus sums up the matter in a few words: 'Et puis qu'on n'avait rien à se dire, on buvait.' With the increase of knowledge and the cultivation of manly sports—the latter being a means of education in themselves—there is good reason to believe, even without statistics, that drunkenness in the British Army is steadily on the decline. It is true that the cultivation of athletic games is attended to an unnecessary extent by conviviality—witness the excited gatherings in the canteen after a popular football or cricket match—but even if an extra quantity of liquor is consumed at these times, the occasional excess is more than compensated for by the habitual abstinence which is necessary for those who wish to engage in manly exercise with any hope of success. The more that fit and proper amusements are provided for the soldier, the more his attention is distracted from drink and other forms of vice. An appreciation of reasonable amusements, as previously stated, necessitates knowledge of some kind, and here the good effects of education are made manifest.

Libraries now exist in all military stations, and it is interesting to examine the list of books which appear to be favourites. Evidence is obtained in this way of the popularity of the better class of works; and by studying the tastes of the men in this matter, and by the careful exclusion of low-class literature, there is a means, not to be despised, for fostering tastes which are incompatible with drunken and dissolute habits.

There is also another means which may appear to be a direct contradiction of what has gone before, and that is to make the canteens as attractive and comfortable as possible. Whether universal teetotalism is or is not desirable is too vast a subject to be entered on here. Whatever individual views may be entertained, there is no getting over the fact that the average man, whether soldier or civilian, will partake of alcohol as a beverage, and this being the case, it is better to make the habit as little deleterious as possible, instead of violently reprobating a custom which, even if undesirable, is nevertheless indulged in by an enormous number of self-respecting people of both sexes, whose lives and conduct are absolutely above reproach. If the soldier has an uncomfortable canteen in barracks, he will drink in the town, where the chances are he will consume bad liquor in company of corresponding quality, and where, being free from military control, he can indulge in libations and in a style of behaviour which would be impossible, or, at any rate, promptly followed by unpleasant consequences, within the precincts of an institution under official management.

Some canteens are the reverse of comfortable, being cold, bare, and often detestably lighted. To maintain uncomfortable and cheerless regimental institutes is the surest way to drive men into the town, and to drive men into the town invariably means an increase of drunkenness and crime.

To understand fully the additional perils to which the soldier is exposed by drinking out of barracks, it is necessary to get an idea of the conditions under which the retail of intoxicants is carried on in England.

The huge majority of public-houses are run on what is known as the 'tied' system; this means in practice that the leasehold or freehold remains with the brewer, and that the tenant is little better than a servant, being subject to short notice to quit, and compelled to purchase his supplies from the owner of the house. A very little reflection will show that this is a one-sided arrangement in which both the publican and the consumer are likely to come off badly, for, assuming the absence of serious competition—a practical

certainty when the houses in the locality are in the hands of a single firm—and a sufficiency of potential tenants, there is nothing whatever to prevent the brewer from selling the worst possible article at the highest possible price. There is, of course, no intention to speak otherwise than respectfully of an admittedly honourable calling, and there is no doubt that with firms of high standing both publican and purchaser receive fair treatment, but unfortunately this is not always the case, and even when a good article has been originally supplied, insecurity of tenure is a strong incentive to the publican to reap the best harvest with the least possible danger to himself, and without regard to the interest of his customers. It is not surprising if, under such circumstances, our national beverage, adulterated by dirty hands, should become a foul and evil mixture largely consisting of refuse material, and in which cheap and doubtful drugs take the place of the native hop. Having regard to the conditions under which the army canteen is managed, it is only reasonable to assume that the bulk of sickness due to excess of alcohol results from drinking outside the precincts of the barracks. Individual cases may not seem to call for much attention, but in spite of the enormous improvement in recent years as regards temperance, the cumulative effect of such cases on the efficiency of the army, and consequently on the national exchequer, is sufficiently serious. In barracks the soldier is practically certain of obtaining wholesome liquor, for the simple reason that, apart from immediate loss, brewers are well aware that the unsatisfactory performance of an army contract is likely to do serious damage to commercial prestige, and, consequently, to be followed by far-reaching results.

At St. Helena the building used as a canteen in the Ladder Hill Barracks was certainly not inviting, and an institution of the nature of a mixed canteen and gymnasium, under the name of ‘The Soldiers’ Home,’ was started in a house in the main street of Jamestown. It certainly promised to have a long and successful life. It entirely paid its own way, and did excellent work in the prevention of crime and disorder. Its inception was due to the late

Major E. H. Peacock, 1st Leicester Regiment, and his action conferred a benefit of a most thoroughly practical and far-reaching nature on the garrison of the island.

In the United States Army the absence of canteens has made itself seriously felt, and at the same time their good is fully appreciated.

Temperance publications usually contain numerous illustrations of the lamentable effects of excessive drinking on individuals, and the statements made in the above class of literature are to be easily corroborated by the experience of everyday life. The effect of alcohol on the individual, and the effect of alcohol on any given community, taken as a whole, must not, however, be confounded. No one will deny the baneful results of intemperance, and it is impossible to form any approximate estimate of the harm that the amount of alcohol consumed in the service exercises on military efficiency considered as a whole. Of course, it may be argued that one soldier useless through drink is in himself a cause of military inefficiency, and that the more such units are multiplied the greater will be the sum total of damage directly due to alcoholic excess. This, in a sense, is perfectly true; but, unfortunately, the effects of intemperance in the army, as elsewhere, extend far beyond the individual himself, so that the actual number of drunkards in the service would be an altogether fallacious indication of the actual harm directly due to excess. The extreme responsibility of military duty should make this fact sufficiently obvious. The evil influence of an intemperate non-commissioned officer would have a far-reaching effect. Such cases are fortunately rare.

The question of beer in the field is one about which there is considerable diversity of opinion. If it is allowed at all, the quantity should be strictly limited, and consumed at stated times—in the evening for choice. Among other instances, I remember in particular one regiment to which I was once attached on service, in which this plan was followed with the very best results. Drunkenness was impossible, and crime almost entirely absent; and I had the opportunity of observing the contrast with another unit

in which a canteen had been established under the same conditions as those which obtain in peace-time at home. The men had been deprived of all liquor for many weeks, and the result, when almost unrestrained indulgence became possible, took the form of a singularly exciting and equally objectionable series of events. I recommended that, in view of the effects of the climate on health, the quantity of beer allowed to each man should be limited to 1 quart per diem —a very liberal allowance under the circumstances. My suggestion, I well remember, was laughed at, possibly on account of my youth and inexperience; but the necessity for restrictive measures became daily more manifest, while the application of the principle embodied in my despised proposal was, I well knew, producing undeniably good results elsewhere.

To sum up the preceding remarks in a few words: it seems likely that drunkenness in the rank and file may best be combated:

1. By games and reasonable recreation generally.

2. By the establishment and care of comfortable canteens and regimental institutes.

3. By the rigid maintenance of sobriety amongst non-commissioned officers.

As an auxiliary measure, canteens might remain closed, as regards general use, until after the dinner-hour; and beer always allowed in the rooms for consumption during this meal, as recommended by the committee on the physiological effects of food, training, and clothing, on the soldier. The uses of alcohol on service should be explained, as far as possible, to all, and if beer is allowed at all in the field, it should only be consumed under the restrictions already described.

Drunkenness among married women in quarters is, in my experience, almost unknown. Its existence, however, cannot be altogether denied, and its effects may be far-reaching. The evil, in fact, caused by a drunken mother extends far beyond the annoyance caused to those who are unfortunate enough to be subjected to her society. It is now well known that infants are brought into the world with their systems

already poisoned by the drink consumed by the mother, and the revolting nature of this fact is intensified by the continual poisoning to which the children are subjected as long as they continue to derive nourishment from the maternal source. The stunted, puny, and generally wretched offspring of a drunken mother owe their physical condition to the alcohol with which they have been saturated from the earliest suggestion of their existence.* Many such children never come to maturity; they are frequently smothered in bed by being rolled upon by an intoxicated parent, or because, being stupefied with alcohol, they are unable to remove the bedclothes which have been carelessly thrown over them.

Soldiers' children, taking all their surroundings into consideration, should be physically and mentally better than children of the corresponding class in civil life, but it would be difficult to prove that they actually are so. As a simple opinion backed by common sense, the question would probably be answered, by most persons, in the affirmative. The soldiers' male offspring can reasonably be expected to make the most desirable recruits, and it is therefore quite worth while to pay some attention to this field for supplying the means of national protection. The male children of a drunken mother should, as a broad rule, be considered as so many recruits lost to the army. It may be argued that the effect exercised in this direction must be infinitely small in proportion to the number of men annually required. This may or may not be the case; at any rate, the consequences to the

* 'Well-known teratologists, such as Niclouse, have demonstrated by experiment the influence of alcohol in the production of deformities, more especially in fowls. Alcohol injected into their eggs on various days was followed by the production of abnormalities in the chickens, such as the presence of eight toes.

'Large numbers of statistics have been collected, both in France and England, which tend to prove that alcohol is a powerful factor in the production of miscarriages—more powerful than tuberculosis, though less so than syphilis. Not only is this so, but of the children born alive a fewer number reach maturity, and a great proportion die, more especially of tuberculous meningitis' (G. Carpenter, 'Alcohol and Children,' *Journal of State Medicine*, October, 1904).

population, either civil or military, cannot be otherwise than bad. In civil life there are no ready means of bringing home to offenders of this kind a sense of maternal responsibility, but in the army well-deserved punishment, in the shape of ejection from barracks, is meted out to women whose maternal duties are not found to act as a sufficient bar to indulgence in drink. Such punishment may make no difference in the habits of the individual, but it certainly acts as a deterrent to those who are inclined the same way. The very presence of a drunken woman, besides its example to the less well disposed, is an insult to self-respecting families and a constant source of annoyance to medical officers and to the authorities generally. I remember one woman who appeared to think it necessary to send for a medical officer whenever she got drunk; and, as her habits were deplorable, calls for professional advice were frequent. Repeated warnings were futile, and promises of amendment speedily forgotten. Ideas of ordinary comfort and decency, if any such ever existed, had long since vanished, and to lie in a drunken stupor, surrounded by her unwashed offspring, and by the fœtid débris of many meals, with doors and windows tightly closed, seemed to be the very acme of physical and mental enjoyment.

This clearly was a case in which the power of the military authorities was exercised for the direct good of the community, for to punish such an instance of habitual misconduct is most assuredly a duty to the State, and this absolutely distinct from purely service considerations. In civil life persons of this kind are, within certain limitations, free from the interference of the law, and in so far as the continuance of their degraded mode of existence is impossible in the army, the latter is the cause of the prevention of habits which are, in very truth, a national danger.

It is almost needless to say that there is no intention in this chapter of making any remarks likely to cause the least offence to soldiers of any rank. Drink and dissipation are by no means peculiar to the service, and taking into consideration the effects of discipline, physical training,

and general surroundings, it may reasonably be asked, other things being equal, whether the army, in decency and law-abiding conduct, does not contrast favourably with the civil population. It is, of course, not intended, in suggesting this question, to institute any invidious comparison, but at the same time it seems reasonable to believe that a community which exacts, at all times, a relatively high standard of conduct must, in a general sense, make directly for the moral benefit of its members.

CHAPTER XXIII

INFECTIOUS DISEASE IN PEACE*

BESIDES all other reasons, the aggregation of large numbers of men in a restricted space renders sufficiently obvious the prime necessity for rigid measures of isolation and disinfection in all military communities. The actual procedure to be employed is fully detailed in regulations for Army Medical Services; but there are certain points worth considering which cannot well be provided for by stereotyped directions, as many diseases classified under the heading of infectious are not to be immediately detected in their initial stages, while at the same time eminently liable to spread, and in the case of measles, for instance, the danger is known to be particularly difficult to avoid. For this reason observation wards should form part of every military hospital.

The requirements for isolation are well known, and need not be stated here; it is plain that the provision of these requirements at every military station would involve a serious expenditure to meet contingencies which might never arise.

It seems occasionally to be overlooked that a soldier in no way loses his right as a citizen as soon as he is attested, and that he is therefore still entitled to those advantages which municipal and other bodies provide for the benefit of the community at large. With the exception of the War Office letter referred to below, I am not aware of any regulation on the subject, but it seems, on the face of it, scarcely sound

* For purposes of convenience, infectious disease is considered to comprise communicable diseases generally, including venereal disease.

judgment to attempt the treatment of men suffering from infectious diseases in a so-called 'special' ward, when a properly-appointed institution, for the support of which the soldier is taxed indirectly, if not directly, is ready to undertake his care.

When a local fever hospital is available there is a distinct pecuniary gain in the removal of infectious cases from barracks, and the cost of maintenance, if charged for, would probably be not much more than that in the military hospital, while detention in the latter entails the risk of serious expense by spreading infection, and thus causing inefficiency.

Many municipalities make a comparatively high charge for the treatment of soldiers, while women and children from barracks are received free. Where a contribution in lieu of rates is paid by the War Office the legitimacy of a charge is doubtful, although I am not aware that the point has ever been argued in a court of law. While considering the pecuniary advantages accruing to any locality from the presence of troops, the above practice cannot be defended on the ground of equity.

A War Office letter (No. 53, Gen. No. 2,649, April, 1905) has stated that 'it is desired to extend, as far as possible, the practice of using civil hospitals for the treatment of infectious cases occurring among the troops.'

It may for many reasons be desired that a regulation should be brought into force making it obligatory on all concerned to take advantage of institutions maintained by local sanitary authorities for the treatment of infectious diseases, whether at home or abroad. The instances where the isolation of such cases within the precincts of the barracks is feasible must be exceedingly small, and residence in married quarters should be made conditional on prompt acquiescence in the immediate removal of any member of a family to an isolation hospital, should circumstances call for the measure. It is, in fact, among the married families that opposition is likely to be encountered, yet the circumstances under which these people live are almost certain to en-

tail the rapid spread of epidemic sickness should such an eventuality arise. A dozen or more families occupying one block; the doors of the quarters opening into a veranda for general use; latrines, in some cases, still common to many; apartments entirely unsuited, on account of structural reasons, for the treatment of the sick; the too common exclusion of air; a combined smell of cooking, ironing, and stale tobacco, together with the indefinable odour associated with the presence of a numerous infantile residuum—such are, without exaggeration, the surroundings in which the barrack child would, if attacked by such a disease as scarlet fever or diphtheria, have to struggle through a sickness which he would almost infallibly impart to those about him.

It is certain that in these cases compulsory removal to hospital is the only course.

A matter which influences the probability or otherwise of the outbreak of infectious disease in barracks is found in the arrangements for school attendance. If the children attend school in the town, there is always a greater risk than if they attended school in barracks; and matters are further complicated in the former case by the compulsion to attend a civil school as long as it is not closed by order of the municipality, although some form of epidemic may possibly be prevalent in the vicinity. Civil authorities are very properly chary of closing the local schools, but, at the same time, infectious disease occurring in the person of a soldier's child is a matter of greater public importance than its occurrence in a civil community. Married families off the strength are another source of danger. The residences of these people should be kept under observation, and the Medical Officer of Health should be requested to furnish information as to the occurrence of infectious disease in the locality. The Medical Officer of Health can render most valuable help in maintaining the health of troops—by keeping in constant touch with him the medical officer in charge can obtain early information of the existence of infectious disease in any houses likely to be frequented by the men, and such houses can then be placed out of bounds. To take an

extreme but by no means an impossible case: a married man living off the strength may call in a civil practitioner to attend a member of his family suffering from infectious disease; the Medical Officer of Health receives the usual notification, but is under no obligation whatever to communicate with the military authorities, and a man from an infected household may mingle daily with his comrades in barracks. Any danger of the kind may easily be prevented by a local arrangement with the civil authorities, and I have never known an occasion when the required help was not courteously rendered.

When cases of infectious disease have to be treated in hospital, there are some particular points connected with their management which are well worth noting.

1. *Kits.*—The kits which are brought to the hospital for disinfection should be carefully checked as soon as they arrive, and any deficient articles should be sent for. This should be done by a letter to the commanding officer, to whom it should be made clear that any articles left behind are likely to spread disease.

This danger is most likely to occur when scarlet fever is in question, and articles of kit, even if stowed away when a man goes sick, may account for a recrudescence of the disease when used again after his discharge from hospital. This is far from an imaginary danger, and many 'return cases' from a similar cause have been reported in civil life.

A very serious danger arises from the fact that a soldier does not possess blankets which accompany him throughout his service. When he reports sick his blankets and bedding are sent to the company store, with other articles of the same kind, and as the above do not bear any distinctive marks, there is no means of tracing the property of particular individuals. With such an arrangement in force it is quite possible for a man to receive the blanket of a patient who is in hospital with scarlet fever, or even something worse. To prevent disasters of the kind it is advisable to recommend to commanding officers that the bedding of all men reporting sick should be kept apart from other bedding until the

necessity for disinfection is definitely known. It is clear that the bedding (including blankets, etc.) of each man should bear a distinctive mark, that it should never be mixed with other bedding when men go to hospital, and that it should never be reissued for use until it has undergone steam disinfection. Of course, in case of infectious disease, the bedding is disinfected as a matter of routine.*

2. *Separation of Convalescent from Acute Cases.*—The convalescent should always be separated from the acute cases. In scarlet fever, relapses are common if convalescents are kept in the same wards as the fresh admissions. At the isolation hospital at Aldershot I followed the plan among the scarlet-fever cases, which were by far the most numerous, of moving a man into the convalescent ward as soon as his temperature was normal. This step answered its purpose very well, and I do not remember a single case of relapse, after it was brought into effect. There is also one other reason for separating convalescent scarlet-fever cases, which has been well pointed out by Dr. Niven, and which should be carefully acted upon. It consists in the fact that 'return cases' are in great part due to the recent association of discharged patients with acute cases. This measure has had a sufficient trial in Manchester to carry conviction as to its value.

Relapses in diphtheria are very common if the convalescents are associated with other cases. Although the former may still harbour the bacilli in their throats, they are without doubt open to infection. This fact incidentally raises the doubt as to whether the bacilli in the throats of the convalescents are virulent or not. It is certain that the hosts are susceptible to the disease, and this being the case, how are they able to harbour with impunity forms possessed of virulent properties? It is an interesting question, but the answer is not at present forthcoming.

3. *The Discharge of Patients.*—In scarlet ever every case should be judged on its merits. Careful disinfection of nose,

* In the South African Command the bedding of each man bears a distinctive mark.

fauces, and ears, should be scrupulously carried out for several days before discharge. Baths should be taken daily. I doubt if the quantity of antiseptics used in the water ever has any disinfectant result worth calling such, but, at any rate, the presence of the above is an object-lesson, if nothing else. No patient should be allowed to leave hospital who is suffering from a discharge from nose, ear, or throat; and, as a rule, the presence of albumin in the urine should be a sufficient reason for detention. Many medical men of great experience do not look on slight desquamation as a danger, but, in the absence of accurate knowledge, the old plan of keeping patients in hospital until it is over is probably the safest.

Diphtheria cases should be carefully watched for nasal discharge. When such cases occur they may be very troublesome. They should be treated with the siphon douche several times a day. There is an ample choice of local disinfectants. It is an interesting fact, in reference to diphtheria, that nasal catarrh is frequently unaccompanied by any constitutional signs, although the bacilli are highly virulent.

The bacilli have been detected in the kidneys, and the possible infectivity of the urine is not to be lost sight of.

It may sound heterodox, but personally I do not believe that it is in the least necessary to maintain the isolation of convalescents as long as their throats contain what are believed to be diphtheria bacilli. There is evidence, as above, that these bacilli are not virulent ; and we now know that the organisms have a wide distribution among children who show no sign of sickness. In fact, if we are to be consistent in the matter, education, as carried out at present, would be scarcely possible. Fresh air and antiseptics rapidly destroy the virulence of any germs that may be in the throats, although I must admit that this conclusion is the result of clinical experience rather than of bacteriological research.

The discharge of enteric patients is a question fraught with great difficulty and anxiety. The matter is discussed elsewhere (see Chapter III., Enteric Fever, pp. 65, 66, and 67).

It is always a difficult problem when dealing with soldiers under isolation to prevent communication with the outside

world, and men are often quite regardless of the results of their own actions as affecting either themselves or others. For this reason a constant watch has to be kept over their proceedings. I was once told by a medical officer of many years' experience that he had, on one occasion, detected a scarlet-fever convalescent industriously packing, with flakes of his recently separated cuticle, a bulky envelope which he had previously addressed to his mother.

On the occurrence of infectious disease in a barrack-room, it is well not only to isolate the patient, but also to isolate the whole of the remainder of the men in the room for such time as the medical officer may think necessary, the time being naturally determined by the incubation period. In the case of diphtheria, it is a sound measure to obtain swabs from the throats of a few of the other men in the room, particularly of the men who have occupied cots near the patient.

Clothing, bedding, etc., is now almost always disinfected by steam. There are many disinfectors of varying degrees of excellence in use; among the best known are Thresh's, Washington Lyon's, the Equifex, and Rex's. The latter was in use at Aldershot, and I found it answer well on the whole, but it took a long time to get the clothes dry after disinfection. In the case of a large public institution this would have been a serious drawback.

The principle of steam disinfection is based on certain well-known laws of heat. When water boils, the temperature ceases to rise, always provided that the pressure remains constant; no matter what the heat of the fire may be, or how long the process is continued, the result is invariable. The question which naturally presents itself is, 'What becomes of the heat?' The heat is employed in retaining the water in the form of steam. When water is converted into steam, the heat by which the conversion is effected no longer serves for raising temperature, but only for holding apart from each other the ultimate particles—viz., the molecules of which water is composed (see pp. 392 and 402). A diagram may help to make this point clear.

In the diagram on the right the molecules are close together;

in that on the left they are kept apart by means of heat, which, being so occupied, is not available for raising temperature. The volume of steam produced is about 1,700 times as great as that of the water which produced it, and the amount of heat which disappears, or which, to use a more common expression, is rendered latent, is estimated as follows: 1 part by weight of water at 100° C. converted into steam at 100° C. requires as much heat for this purpose as would raise 537 parts of water through 1° C.; differently expressed, we may say that, 1 calorie being the amount of heat necessary to raise 1 kilogramme of water through 1° C., 537

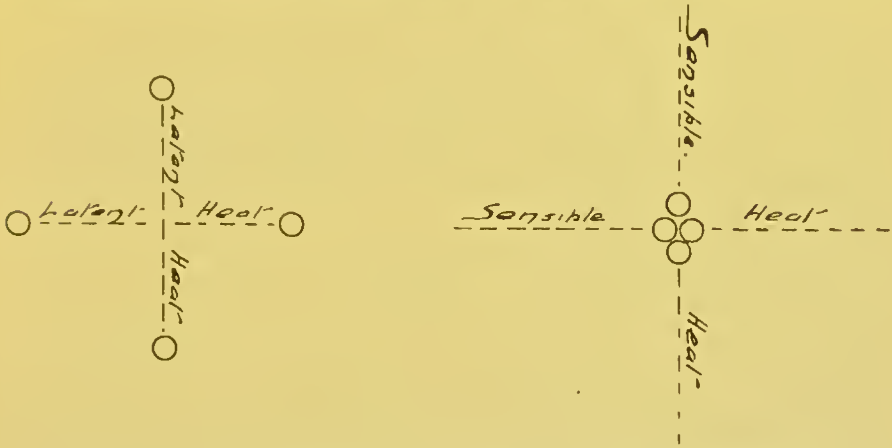


FIG. 54.—DIAGRAM SHOWING ACTION OF HEAT ON MOLECULES OF WATER.

Drawn by Quartermaster-Sergeant Revill, R.E.

calories become latent for the purpose of changing 1 kilogramme of water into steam. When the steam is condensed into water, the heat which has held the molecules apart now becomes available for ordinary heating purposes, or, in other words, is converted into sensible heat; and, as stated above, the volume of water produced is 1,700 times less than the volume of steam which produced it. We thus see that contraction in volume and rise in temperature are results inseparable from the change in question. These two results form the basis of steam disinfection. When, for instance, a current of steam is passed into a woollen article, some of the air is displaced, and as the steam, by contact with the wool, loses heat at the same time, it is converted into water,

the change being accompanied by the contraction which has already been mentioned. A vacuum is consequently formed, but is immediately filled up by more steam, and the process is repeated, the latent heat of the steam being liberated as soon as condensation into water takes place.

For disinfecting purposes steam may be classified as follows :

1. Saturated steam.
2. Superheated steam.
3. Current steam.
4. Confined steam.

1. Saturated steam means steam which condenses into water as soon as it comes into contact with any substance at a lower temperature than itself, or as soon as it is subjected to any increase of pressure. It is evident, therefore, that the slightest reduction in either of the above directions will effect the required object.

Saturated steam is not necessarily steam at 100°. If water is boiled at a pressure higher than that of the atmosphere—which is easily done by placing a pressure-valve on the outlet of the vessel—the boiling-point is raised. The following table, which presumes that the air has been expelled from the vessel, shows the boiling-point of water at various pressures:

BOILING-POINT OF WATER AT VARIOUS PRESSURES (AFTER REGNAULT).

Above ordinary Atmospheric Pressure.*	Pressure indicated by Manometer.	Temperature.	
		Degrees C.	Degrees F.
0 atmosphere	0·0 pounds to the square inch	100·0	212
1 "	14·7 " " "	120·6	249
2 atmospheres	29·4 " " "	133·9	273
3 "	44·1 " " "	144·0	291
4 "	58·8 " " "	152·2	306
5 "	73·6 " " "	159·2	318
6 "	88·3 " " "	165·3	329

* One atmosphere = 14·7 pounds to the square inch, or 760 millimetres of mercury.

The boiling-point can also be raised by the addition or certain salts to the water. The steam produced has the same temperature as the solution, but it condenses on coming into contact with a cold, insoluble substance, and the temperature of the condensed moisture is not higher than 100°. Expressed shortly, saturated steam, whether at atmospheric pressure or at higher pressure, is always condensed if the pressure is raised or the temperature lowered.

2. Superheated steam is steam of which the temperature is raised without increase of pressure. Before such steam can be condensed its temperature must fall to that of the boiling-point corresponding to the existing pressure, or else the pressure must be proportionately increased. It will be clear from the above that superheated steam does not condense with the same readiness as saturated steam—superheated steam behaves as a gas; saturated steam behaves as a vapour—meaning that the first tends to retain its form as steam, and the latter to lose it under the least provocation, in the form either of a reduction of temperature or a rise of pressure.

Superheated steam is a bad conveyer of heat; saturated steam is a good conveyer of heat, as it is easily condensed, and its latent heat becomes apparent as sensible heat.

3. Current steam simply means steam which flows through the objects to be disinfected, in a more or less powerful stream.

4. Confined steam is steam retained in the disinfector by means of a valve on the outlet.

For purposes of general effectiveness the use of saturated current steam under pressure is considered to yield the best results.

The disadvantages of superheated steam will be evident from what has already been stated, and it is easy to see that confined steam will not readily expel the air contained in the substance to be disinfected. Air not only impedes the entrance of steam, but, being a bad conductor of heat, it also impedes the rise in temperature which is necessary for the destruction of germ life.

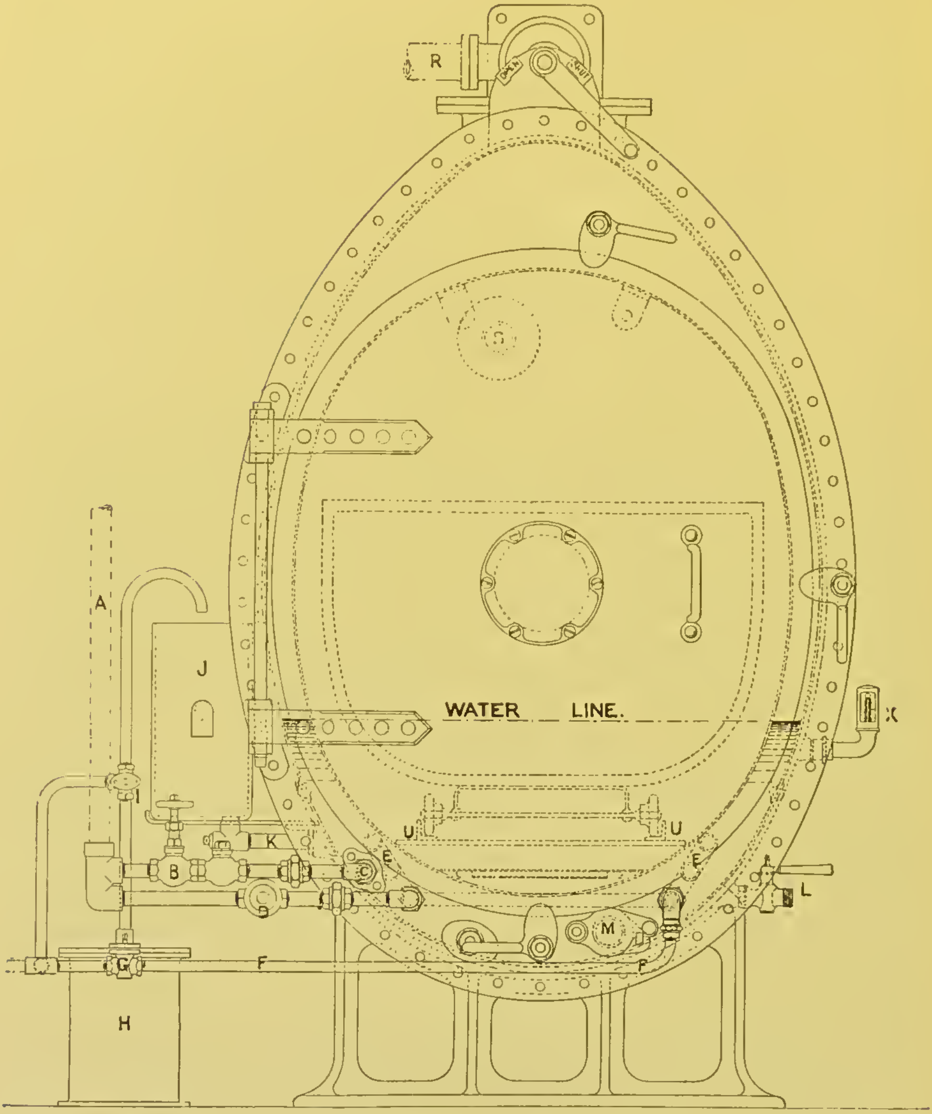


FIG. 55.—THE 'THRESH' CURRENT STEAM DISINFECTOR WORKING AT ATMOSPHERIC PRESSURE: FRONT ELEVATION, SHOWING ARRANGEMENT OF FITTINGS, ETC.*

A, Steam-pipe from boiler; B, inlet valve to live steam injection-tube C; C, live steam injection-tube; D, inlet valve to heating-coil E; E, copper heating-coil; F, condense-pipe from heating-coil; G, three-way cock to bye-pass steam-trap H, when required; H, steam-trap; I, three-way cock to byc-pass feed, cistern J, when required; J, feed-cistern with overflow and feed connection; K, supply-pipe between cistern and jacket; L, draw-off tap to empty jacket when required; M, air inlet valve to large coil N (in double-door machine at disinfected end).

* Figs. 55 and 56 are reproduced from designs kindly supplied by the Thresh Disinfector Co.

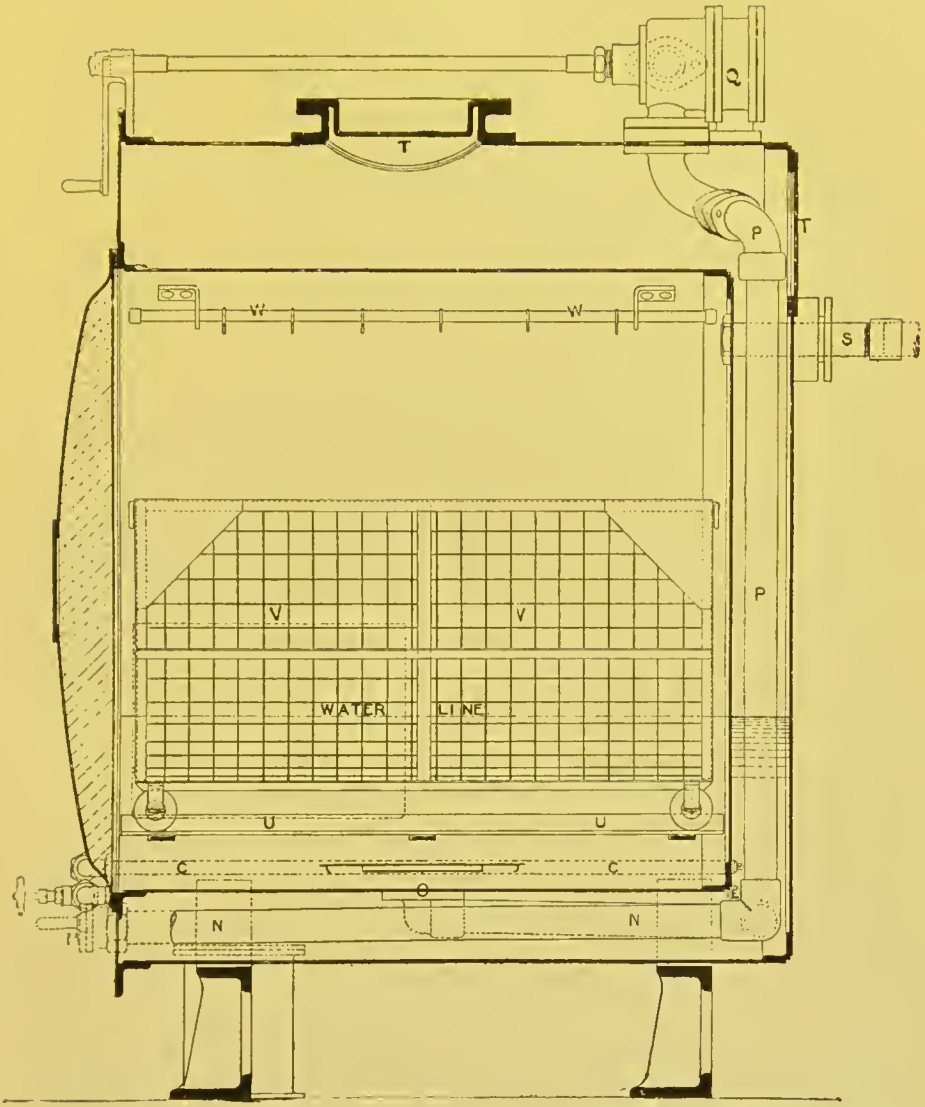


FIG. 56.—THE 'THRESH' CURRENT STEAM DISINFECTOR WORKING AT ATMOSPHERIC PRESSURE: LONGITUDINAL SECTION, SHOWING ARRANGEMENT OF FITTINGS, ETC.

N, Large coil for passing steam or hot air to inner chamber; O, inlet port for steam and hot air into inner chamber; P, connection between large coil and steam valve Q; Q, valve to pass steam from jacket to inner chamber, or from jacket to exhaust-pipe R; R, exhaust steam-pipe from valve Q; S, exhaust-pipe for either steam or hot air from inner chamber; T, manhole to give access to jacket; U, movable rails to support wire basket V; V, wire basket to receive articles for disinfection; W, rods and hooks to receive articles for disinfection; X, thermometer.

Modern disinfectors usually consist of a central chamber, in which the articles to be disinfected are placed, and an external chamber or 'jacket,' into which steam is also admitted, and which serves to check condensation and loss of heat. The articles to be disinfected are put in at one end of the chamber and removed at the other end; and when the disinfector is in a building, risk of recontamination is obviated by means of a partition wall at right angles to the long axis of the chamber, so that the opposite ends of the disinfector are in separate rooms.

The advantages and disadvantages of high and low-pressure current steam disinfectors, and the comparative disadvantages of confined steam, are ably set forth by Professor Sheridan Delépine, and in this connection I cannot do better than quote his own words:

Low-pressure current steam disinfectors 'are generally sufficient for practical purposes, and destroy all known pathogenic germs in from 15 to 30 minutes. . . . They supply steam, which, where wetting is successfully avoided, produces less alteration of the goods than steam at a higher temperature; they allow a simpler construction to be adopted, may be made of lighter material, and therefore should be less costly; their lightness makes them specially suitable where portable disinfectors are needed. Their disadvantages are that disinfection by steam at low pressure is slower than disinfection by steam at high pressure,' and that 'articles which have been submitted to dry steam at a temperature above 100° dry more quickly than articles which have been treated by steam at 100°. . . . Air escapes so slowly from a damper in which steam is confined that the constructors of the old disinfectors have been compelled to resort to various devices to secure the expulsion of air within a reasonable time.'*

Although, as already stated, current steam under pressure generally yields the best results, steam under ordinary atmospheric pressure is, on account of its safety, certainly the best for use in the service. Among the many disinfectors on

* Delépine.

the market, the Thresh for all-round utility is certainly the best. The usual principle is that of saturated steam at atmospheric or at some higher pressure. Figs. 55 and 56 respectively show front elevation and longitudinal section of a Thresh current steam disinfector working at atmospheric pressure. I have had experiences of both fixed and portable types, and find them excellent; they are perfectly easy to work, free from risk of an explosion, and effect the purposes for which they were designed. For disinfection of germs not more resistant than the spores of anthrax bacilli 45 to 120 minutes is required, including the heating of the disinfector; the difference in times depending on the presence or otherwise of associated material.

Formalin, or, to give it its scientific name, formic aldehyde, $\mathrm{CO}\genfrac{}{}{0pt}{}{\mathrm{H}}{\mathrm{H}}$, is the form of chemical disinfectant commonly used in the service. It is applied either in the form of a spray or a vapour. If used to spray the garments there is a chance of failure, unless great care is taken, so that it is safer to soak the articles in the solution. With this saving clause the use of formalin can be strongly recommended; it is certainly very irritating to eyes and throat, but this is a minor disadvantage. I believe that an objection to its use has been based on the ground that it precipitates albumin, and so forms an impervious coating which prevents penetration. This, I think, is imaginary. I have carried out a series of experiments by direction of the War Office on the relative efficiency of spray and vapour, and I am fully convinced of the efficiency of each, if used with ordinary common sense and care.

Among other disinfectants are perchloride of mercury, sulphate of copper, sulphate of iron, and chloride of lime.

Perchloride of mercury is very poisonous; it corrodes metals, and forms an insoluble compound with albumin; although it is a powerful germicide, its value is seriously discounted by the properties just named. Sulphate of copper and sulphate of iron act largely by decomposing sulphuretted hydrogen. Chloride of lime acts by setting free

chlorine in the presence of an acid. None of these should be employed if formalin is available. There are also the coal-tar preparations, such as carbolic acid, which are useful in solutions of suitable strength.

It is important to remember that repeated disinfection by steam or boiling water will very soon destroy blankets and other woollen articles. When the blankets are washed outside the hospital, laundries may decline to receive them unless they have been disinfected by steam. This is, in itself, a good reason for washing clothes, etc., inside the hospital. Blankets which need washing can be placed in a disinfecting solution, and afterwards washed in the usual way. Constant washing damages blankets, besides being unnecessary. Sheets are, naturally, always used, and the blankets do not, or should not, come into contact with the patients.

Leather articles are ruined by steam, a fact occasionally forgotten. It is not so long ago that an assistant surgeon, whose zeal outran his discretion, being employed on plague duty, insisted on disinfecting, by this means, the polo boots and saddle of an officer who was proceeding to Simla. The owner, who had waited with considerable impatience for the completion of the operation, had his property returned to him as three shapeless masses of slimy pulp. Boots and other leather articles can be dipped in a solution of izal and left in it for half an hour or more. In some cases destruction by fire may be the safest course, but such a very radical proceeding is not often necessary.

In India it is well known that religious gatherings are fertile means for the dissemination of disease. The surrounding country is comparatively drained of human beings, whole families emigrating, for the time, to the place of meeting. Persons of all ages and all stations of life, children in arms, beggars, cripples, the sickly and diseased, are all herded together in the bazaar of some crowded native city. It would require a special sanitary staff and the outlay of large sums of money to carry out effectual sanitary administration for the mass of humanity which swarms in the big cities at the Feast of Mohurrum, or other popular religious

celebration. The more attractive features of Mohurrum cover about four days, and, being one of the most important festivals, it is attended by a correspondingly large number of devotees. Except those who are actually resident on the spot, and who may form only a comparatively small proportion of the whole, these persons are devoid of anything in the nature of sanitary appliances, and the necessity for such, if present at any time to the minds of most of them, is overlooked under the influence of religious excitement It is, therefore, not difficult to realize the possibilities which may result from this combination of filth and fervour.

At Delhi, the fort in which the British troops are located is within a quarter of a mile of the native bazaar, so that the men are quite liable to share in anything in the way of disease which has either been conveyed to the locality by the persons of pilgrims, or which has originated in the concourse itself. Delhi is by no means singular in this respect. At other stations there is the same proximity to the bazaar; a state of things undesirable at all times, and particularly so when the neighbourhood is polluted by the presence of an unwashed mob, in which some form of infectious disease is almost sure to be present. It would be an excellent measure if the immediate localities where the larger festivals are held were always placed out of bounds during the period of celebration. Besides the question of the possible effects of large native gatherings, there is no doubt that the proximity of bazaars and of the poorer habitations has often a decidedly unfavourable effect on the health of British troops. The influence, in this connection, of both malaria and enteric fever has already received attention.

Punkah coolies are drawn from amongst the lowest classes. Great care is needed in carrying out medical inspections of these men, as the latter are commonly most horribly dirty. Enlarged spleens should always be looked for, as cases of this kind may prove sources of malarial infection.

The abolition of the Contagious Diseases Acts, coupled with the fact that there is no reasonable probability of their ever being resuscitated, naturally limits the discussion of

measures adopted for the limitation of certain preventable troubles.

Whether men of actually intemperate habits suffer more than others from venereal disease is a question which, for the present, should be considered as doubtful. An answer could only be forthcoming after prolonged and patient inquiry, and even then the information could scarcely be exact, as it would be almost impossible to formulate a definition, which would give general satisfaction, of the term 'intemperate habits,' and it is, in addition, very certain that the alcoholic is not exactly the person best qualified to give evidence of the extent to which he indulges in his favourite pastime.

The improvement, in this direction, in our army has doubtless been considerable, and, although the matter does not admit of definite evidence, there is every reasonable ground for believing that this good result is the outcome of the well-managed regimental institutions, games, athletic sports, and the many humanizing influences and comforts which now surround the soldier. Reasonable amusements are provided for all tastes, so there is no reason why the soldier off duty should find time hang heavily on his hands. Education has helped greatly, for there is no doubt that the more knowledge a man possesses the greater are the possibilities in the way of rational pursuits.

Reference may here be made to the effect of barracks in towns. Under such circumstances men are distinctly handicapped in the way of temptation. St. Helena was an excellent example of this fact, as Jamestown offered pastimes of a most questionable nature. For certain months of the year the troops were camped on Deadwood Plain and in the vicinity of Longwood House. The natural surroundings were all that could possibly be desired for the maintenance of health ; spirits were not obtainable ; cricket and football were popular ; and not only did the men improve in every respect, but it is well known that the change was eagerly looked forward to and thoroughly enjoyed—a sufficient proof that indulgence in squalid vice is not in the least essential to the soldier's happiness.

It would be interesting to know whether there is a greater prevalence of venereal disease among soldiers than amongst civilians of the same class. It is certain that a raw youth, with absolutely no knowledge of the world and of defective education, whether he be soldier or civilian, if placed amongst the temptations of a large town, will run every risk of succumbing to those influences the effect of which is certainly not limited to the army. There is, indeed, no particular mystery surrounding this subject as affecting military life, the active causes being practically the same everywhere.

The two great principles of prevention are as follows: (1) The avoidance of the exciting cause; (2) healthy occupation of mind and body.

The former principle finds practical application in the establishment of barracks as far as possible from populous centres, and the latter is now energetically carried out in the service by means already mentioned. In India, during the hot weather in the plains, physical and mental idleness for many hours of the day is unavoidable, and the opportunities for indulgence in vice are, in some stations, brought almost to the doors of the rooms. Although cantonment magistrates control the numbers of persons actually allowed to live in cantonments, they cannot possibly institute any effectual means of checking the peregrinations of what a medical officer of high rank once officially styled the 'ambulatory prostitute.' The evil can, to some extent, be dealt with by the police; but when the latter are natives, the difficulties to be surmounted are serious, and the discharge of this duty is not likely to lead to amicable relations with European troops.

The comparatively recently introduced system of keeping men suffering from syphilis under continuous treatment and observation while they are out of hospital, together with the systematic recording of cases, has everything to recommend it. The general scheme is as follows:

A man on reporting sick with suspicious symptoms is admitted to hospital with a provisional diagnosis which is recorded in pencil. If the case proves to be one of

syphilis, the diagnosis is entered in the Syphilis Register. Cases which are clearly syphilitic on admission are recorded in the Syphilis Register at once. Every case is briefly taken, but no essential particulars are omitted. The information relative to each man is recorded on a separate sheet, and each sheet accompanies the person to whom it refers until he has remained free from symptoms for one year after the termination of treatment. The sheet is forwarded direct, when a unit is transferred, to the medical officer in charge of the hospital where the sick are treated. A nominal roll is also forwarded of the men attending hospital for treatment; the latter usually takes the form of mercurial injections. It is almost too early to form any definite opinion of what the results will be, although it is only reasonable to expect that they will largely diminish the sum total of inefficiency from this cause.

Of course this scheme, excellent as it is, does not touch the question of prevention, and in this connection the Army Medical Report for 1907, on the health of troops serving in India, is particularly instructive.*

Before leaving the present subject, it may be stated that the execution of many sanitary measures in India, including those relating to the present subject, is dependent almost entirely on the action of cantonment magistrates, an arrangement that, as far as personal knowledge justifies an opinion, yields good results, but whether this is always the case is another matter.

Questions of local administration in India cannot be discussed here, except in so far as they affect the question of health, and in this latter connection there does not appear to be any adequate reason why cantonment magistracies should not be conferred on medical officers. If this innovation were introduced, many proposals affecting health could be dealt with on the initiative of their originators, instead of being left to the decision of officials who cannot be expected, in the absence of professional training, to invariably grasp the full importance of all such matters. This

* Army Medical Report for 1907, pp. 109 and 110.

question forms part of the general principle concerning the investiture of the medical department with an authority from which its representatives are now excluded. In India, especially, a change in this direction might be expected to prove satisfactory; prejudice and custom are strong barriers, but in view of the manner in which drastic reforms in the medical services were accepted by the army at large, it may be reasonably anticipated that proposals such as those indicated would receive generous consideration.

CHAPTER XXIV

INFECTIOUS DISEASE IN WAR

The subject of military sanitation on service naturally divides itself into two main branches, each of which contains a multiplicity of details of varying importance. The first branch refers to the prevention of disease in armies in the field; the second branch refers to the prevention of the spread of disease, after the latter has once come into existence. The prevention of disease comprises such matters as water-supply, refuse disposal, food, clothing, etc.; while the prevention of its spread not only includes many of the preceding, but also the subjects of isolation, disinfection, and means for the removal of cases of an infectious nature. The last three points only will be dealt with here.

Isolation.

To make the practical aspect of this question clear, the preliminary discussion of certain other matters is desirable. It can, in the first place, scarcely be sufficiently insisted upon that the principal ailments to which troops on service are liable are of a communicable nature. Without attempting to enter into minute details of pathology, and using the terms which will be found below in a clinical sense only, it will probably be admitted without demur that enteric fever, simple continued fever,* dysentery, and diarrhœa, are, above all others, those forms of sickness which, according to universal experience, have from time immemorial unrelentingly followed the footsteps of armies in the field.

* Returned, under a recent regulation, as 'pyrexia of uncertain origin.'

Under conditions of peace and civilization both enteric fever and simple continued fever have been officially recognized by the Government of the country as being infectious, and they are accordingly comprised in the schedule of compulsorily notifiable diseases contained in the Public Health (London) Act, 1891, and the Infectious Diseases (Notification) Extension Act of 1899. Sanitary authorities have in some cases, with the consent of the Local Government Board, extended the provisions of the Act to diarrhœa, and it is likely that the failure to include dysentery is due to the fact that it could be included under the previous heading, and not to the unlikelihood of its spread, should it ever chance to come into existence. The infrequency of the disease is also, in all probability, another reason for its omission.

As it can be fully accepted that Acts of Parliament such as those in question are based on facts the accuracy of which have been proved by the highest scientific evidence, the necessity for certain recognized measures for the prevention of the spread of the diseases referred to may be granted without seeking for further proof. Proof in plenty could be forthcoming if required.

It is a circumstance occasionally overlooked that the very diseases with which medical officers on service are principally called upon to contend are of the same nature as those which experience has shown to be capable of spreading themselves, if unchecked, throughout communities into which they have been introduced. It may therefore be interesting to see what provision is to be found in the field for grappling with forms of sickness such as those in question, which, as experience foretells, are almost certain to occur in every campaign, and which, even under conditions of civilization, as evidenced by the Acts above referred to, can only be held in check by compulsory measures of prevention. Before proceeding further, it should be explained that the following remarks apply only to field medical establishments which accompany and form part of the fighting force, and in no sense to hospitals on the lines of communication and at the base, as in both the latter the conditions which exist are

likely to resemble those found under ordinary circumstances of peace. The first-named establishments for the treatment of sick and wounded formerly comprised field hospitals in the proportion of one to each brigade; and occasionally of bearer companies, in circumstances of emergency. Both these last-named establishments were only designed to give temporary aid. It has in recent years been decided that they are to be combined in a single unit under the designation of a 'field ambulance.' The general scheme appears excellent, but if the experience of the past is to be a guide to the future, some consideration of the system which has been superseded should be useful.

Each field hospital, according to regulation, was supposed to accommodate 100 sick, or, roughly, 3 per cent. of the force, the effective strength of a brigade being estimated approximately at 3,000; in the field ambulance the percentage accommodation would be about the same, it being remembered that 'paper' strength is not the same thing as 'effective' strength.* It is evident from a simple calculation based on these figures that, having regard to the sickness which may be reasonably anticipated to occur in all campaigns, and to the casualties of another nature which are essential features of active hostilities, either the men must be constantly sent elsewhere, or field hospitals—including in the term 'field ambulances'—will become hopelessly overcrowded. In South Africa it was estimated that accommodation at the rate of 10 per cent. of the total force would be required.†

When field medical establishments came into existence it was very plain that the prospect of utilizing them for the prolonged treatment of cases of serious or infectious disease could never have been contemplated. Apart from the question of numerical accommodation, the organization

* Three field ambulances accommodating 150 patients each are allotted to an infantry division, and four field ambulances accommodating 50 patients each are allotted to a cavalry division (see p. 501).

† See Question 3,519 and Questions 671 and 672 (evidence of Sir William Wilson before the Royal Commission on the South African War).

and equipment are in no way adapted for any purpose of the kind. The shelter consists of bell-tents, the largest pattern with a capacity of 672 cubic feet; and as each tent is designed to accommodate four patients, the occupants are allotted a space of 168 cubic feet per man. There are no hospital diets, no hospital clothing, no beds, no means of ablution worth calling such, and no means of thorough disinfection whatever. It is clear that our official forbears held the common-sense view that the fighting line is no place for the continuous treatment of sick. It cannot, indeed, very well be otherwise if field medical establishments are to retain their mobility, as the equipment carried has to be compatible with the maintenance of the above feature. A field hospital might, for instance, be so encumbered with comforts for the sick and wounded as to be utterly useless. In the words of Surgeon-General Gubbins, 'a field hospital ought to be an exceedingly mobile unit, which can follow the army, say, at twenty-five miles a day, unencumbered by bedsteads or other heavy equipment.'*

It is true that in Natal, after the relief of Ladysmith, an enormous number of comforts were forthcoming from aid societies and from other sources. Hospital clothing, pillows, chairs, fans, eating utensils, muslin covers for food, and, in some cases, beds were distributed amongst the patients, so that, as far as physical comfort went, the spring of 1900 saw the sick of the army of Natal placed under surroundings which were probably unique in the history of war. Having suffered severely from illness myself at this time, I can speak with full appreciation of the care which the sick received, and of the excellence of the supplies which kept them alive. The existence of creature comforts and the unremitting exertions of the hospital attendants could not, however, take the place of what was essential and what was, at the same time, wanting—namely, the isolation of cases which could scarcely fail to spread disease amongst those patients who were under treatment for wounds or ailments of

* See Question 3,943, Report of Royal Commission on South African War.

a non-communicable nature. The absence of what was actually required was no fault of the medical authorities. Sickness had to be treated on the spot, and the best arrangements possible had to be made. It may be remarked incidentally, as a pleasing circumstance, that in spite of certain irresponsible critics, whose questionable philanthropy has fortunately almost entirely passed into the limbo of oblivion, the fact that the medical department fully rose to the occasion has been recognized by persons who, in view of their experience, were singularly well qualified to express accurate opinions.

Isolation was carried out, as far as circumstances allowed; but it was impossible even to make the attempt to do so in any but the most imperfect manner. To have given separate tents to men who were suffering, or who were suspected to be suffering, from disease likely to spread would have been utterly out of the question. The accommodation was stretched to its utmost extent, so that to have limited the number in certain tents would have meant serious overcrowding elsewhere. No tents were specially provided for isolation purposes. Had there been any such, matters might have been slightly better, as, at any rate, it would have been possible to have obviated the occupation by men clearly suffering from enteric fever, of tents which were used later on for an entirely different class of cases. I have more than once seen a tent, allotted to an officer doing duty, which bore traces most strongly suggestive of previous occupation by patients suffering from one of the prevalent disorders.

The tents, as previously stated, were of the bell pattern, and in these ventilation is at all times bad, and there is practically no ventilation at all when the flies are down and the door laced up. There are, it is true, a few absurdly small openings at the top, which are presumably intended as apertures of exit, but the effect of which can be safely disregarded, so that even under the most favourable circumstances the foul and heated air has no adequate means of escape, but must of necessity collect in that part of the tent which is above the opening of the door. The air,

being in contact with the heated canvas, has its temperature raised, by conduction, above that of the external atmosphere; so that the occupants of these tents were subjected to an additional insanitary influence besides those already enumerated. The chances of infection under these circumstances cannot, of course, be worked out with mathematical accuracy, but they are so far considerable that there is every reasonable ground for accepting the belief that men suffering from enteric fever, dysentery, or the like, must have communicated their ailments to those with whom they were in daily contact.

Reviewing the above statements, it seems fair to conclude that, under conditions such as those which obtained in South Africa, effectual isolation in the field, when large numbers of sick have to be dealt with, is, as a rule, impossible; but that the provision of a certain number of isolation tents is desirable, with the object of insuring that some, at least, of the tents are used for that purpose only. The tents for the use of officers or orderlies should never be used for the treatment of the sick, and to fully carry out this idea the tents should be divided into three classes, each class bearing a distinctive mark. The classes might be as follows:

1. For hospital staff.
2. For offices, stores, and dispensary.
3. For ordinary sick.
4. For isolation purposes.

If possible, No. 2 might be further divided into tents for:

1. Offices.
2. Stores.
3. Dispensary.

The results that might be expected to flow from this proposal would, under the stress of active hostilities, be far from brilliant, but even this somewhat gloomy outlook need not act as a barrier against the adoption of a measure which could not possibly do any harm and might do some good;

it would, at least, be a practical protest against the aggregation of a variety of diseases within the fœtid precincts of a bell-tent.

Disinfection.

The absence of adequate means of disinfection in field hospitals has already been mentioned.

Treatment in these establishments means, among other things, that the patients are practically in contact with an absorbent surface—namely, that of the earth, which is soon saturated with morbid excreta; things cannot, indeed, very well be otherwise. A patient suffering from high temperature, or the weakness which accompanies a prolonged flux, is far more likely, when occasion arises, to roll over on his side and pass his water on the floor of the tent rather than to wait the advent of an overworked orderly bearing the prescribed means for sanitary micturition. The means of exit are, certainly, not far distant; but the chances are that even if a sick man, suffering as above, reaches the door, he will obey the call of Nature on the spot, which, after all, is as much as can reasonably be expected of him. If the door is laced up he has to accommodate himself to circumstances. In a field hospital to which I belonged, in Natal, the necessary means for such purposes was left in the tents, near the more serious cases, but the supply was not so fully equal to the demand as to insure the absence of acts of uncleanliness, and some patients who might well have gone to the authorized place failed to do so through ignorance or sloth; it must also be remembered that we were dealing with disease on a scale that would have paralyzed the resources of many well-appointed hospitals at home. Putting aside the question of the sick, it is most unlikely that the average soldier is going to walk possibly fifty yards in the night, often in torrents of rain, for the sake of complying with an arrangement which he probably looks on as the outcome of a fatuous and malevolent desire on the part of the authorities to interfere with his comfort and convenience. It need scarcely be observed that urine was not likely to be

the only source of pollution in and about the tents of the South African field hospitals; every form of filth which tends to collect, not only about the persons of the sick, but also of the healthy, contributed in a greater or lesser extent to the general result, so that the area comprised within, and some extent beyond, the limits of the hospitals soon became saturated with organic material and a breeding-ground for countless myriads of microbial forms of life.

Having regard to preceding statements, it is almost certain that one of the most prolific sources of pollution in field-hospital camps in South Africa was indiscriminate micturition on the part of the men, and in view of the bacilluria which occurs in enteric and allied affections—*i.e.*, paratyphoid fever—the spread of such diseases by the means indicated was in every probability absolutely insured. That the canvas of the tents shared in the general pollution is a matter which has already been referred to, and concerning the certainty of which I have satisfied myself by ocular proof.

The personal clothing of patients may, for purposes of convenience, be considered to include blankets or other kinds of bedding. These are fertile sources of infection. In the earlier periods of the campaign in Natal, the sick in the field had to remain in their khaki clothing, and the articles of kit of men who died in hospital were sent back to their regiments in the ordinary way. Very often there was no opportunity to attempt disinfection, and, of course, it was not always necessary.

In the spring of 1900, when a certain amount of hospital clothing was sent into the field for the sick, the uniforms of the men who happened to be the lucky recipients were all stored in common, irrespective of the maladies of the owners, in improvised pack stores; indeed, no other arrangement was possible. It is of interest here to note that, according to the researches of Germano, the typhoid bacillus can retain its vitality in clothing for upwards of a month.*

* *Zeitschrift für Hygiene*, 24, 1897, No. 3, p. 403.

In the tents men largely used their blankets in common, and the same custom prevailed as regards eating and drinking utensils. The distribution of food, in spite of constant care, was partly regulated by the patients themselves, and the man with a slight ailment was glad enough to finish the milk which the fever or dysenteric patient did not want, and which, in addition to its other attractions, was probably swarming with flies. No supervision could possibly check such irregularities, and repeated warnings, although they doubtless did some good, were largely a waste of breath.

Orderlies did what was possible to observe the principles of cleanliness in which they had been instructed; but with one suit of khaki in which a man has been marching and sleeping for six months or more, and in which he has carried out all sorts of nameless offices for the sick, coupled with the fact that the only satisfactory means of ablution were such as he could find for himself, it is quite reasonable to assume the likelihood of his having become a moving disseminator of certain of those very diseases to the victims of which it was his function to minister.

During the fighting at and about Potgeiter's Drift in the latter part of January and beginning of February, 1900, the sick and wounded lay on waterproof sheets only. There was a certain advantage in this arrangement, as disinfection was a simple matter. At Surprise Hill and Hyde's Farm, after the relief of Ladysmith, the sheets were largely replaced by stretchers, and, as the latter were used for every variety of case, it is very probable that they helped to spread infection. Efforts were made to prevent contamination of the stretcher by placing the waterproof sheet between the body of the patient and the canvas, but this plan was not satisfactory, as there were no means of fastening the sheet to the stretcher, and the former was soon displaced by the restless movements of sick men.*

* An account of an adjustable waterproof cover, designed by the author to prevent contamination of the stretcher, will be found at p. 25, vol. i., of the *British Medical Journal*, 1903.

Reviewing what has gone before, it appears that the following are distinct subjects for disinfection :

1. The excreta of the sick.
2. Soil of field hospitals.
3. Tents of field hospitals.
4. Clothing and blankets of patients.
5. Eating and drinking utensils.
6. Hospital attendants.
7. Stretchers.

1. Excreta of the Sick.

When in charge of a field hospital in South Africa, I directed that the hospital receptacles for the excreta of all men suffering from suspicious illness should be partially filled with a strong antiseptic solution, in order to effect, as far as possible, immediate disinfection. I do not think, however, that this plan was particularly successful ; it may have done what was required in the case of liquid excreta, but it could not possibly have had much effect on solids. On another occasion I should certainly resort to boiling when able to do so ; any old iron vessel will answer admirably as a sterilizer. Bed-pans can be dipped in bodily, so that any adherent matter is either soaked away, or else robbed of its dangerous potentialities by the heat of the water. Close stools can be easily scalded out with boiling water. I have tried this plan in peace-time, and find it cleanly, generally applicable, and efficacious. I must admit that I have only tried it on a small scale. If a large number of sick had to be dealt with, Major Cummins' sterilizer would be invaluable.

It is sincerely to be trusted that burning will be altogether prohibited in the public service. A certain quantity of matter to be disinfected adheres to the pan or other receptacle, so that the process is only partial. The pans, it is true, are rinsed out with perchloride of mercury or other antiseptic, but solutions of this kind have not much penetrative power on the fæcal remnants they are supposed to disinfect, and the perchloride is, of course, singularly inapplicable in the case

of albuminous material. These, in themselves, appear to be sound reasons for abandoning a measure which, in addition to being ineffectual, is often the cause of an exceptionally offensive form of nuisance.

Other means of disinfection consist in thoroughly mixing the excreta with chloride of zinc, sulphate of copper, or the like, by means of a stick, which is used for stirring purposes. Considering the amount of enthusiasm with which the normally constituted man is likely to devote himself to such a task, the measure can only prove as useless as it is disgusting.

2. Disinfection of Soil in Field Hospitals.

This can only be done by shifting the site of the camp, by which means the supply of organic pabulum is withdrawn from the soil, and certain pathogenic forms, notably enteric bacilli, disappear by a process of nature.*

3. Disinfection of Tents of Field Hospitals.

The introduction of a system of separate tents for staff, ordinary sick, and infectious cases, has been suggested above; but this scheme can, at best, be only partially successful. In all cases the internal canvas of tents which have been occupied by enteric cases, or the like, should be well scrubbed with strong carbolic lotion or other antiseptic before striking camp.

In the case of marquees spraying with formic aldehyde or glyco-formol would probably do all that is required.† The tents should also be struck, turned inside out, and left exposed to the sunlight and air for as long as possible. It would be almost impossible to scrub the whole of the interior of a marquee while the tent is standing.

* Report of the Medical Officer of the Local Government Board for 1899 to 1900, p. 525; also Annual Report for 1902 of Sanitary Commissioner with the Government of India.

† Houston, 'Disinfection of Schools,' the *Practitioner*, 1902; also Foulerton, 'Room Disinfection,' *Journal of State Medicine*, November, 1904.

4. DISINFECTION OF CLOTHING AND BLANKETS.

The safest and most satisfactory way of doing this in the field is by boiling water; an ordinary Soyer's stove answers well for the purpose. Some care must be exercised, as the capacity of the stove is limited, and if a blanket is thrust in more or less folded up it will reduce the temperature of the water below the boiling-point, and germs which are in the inner folds will escape. I may take this opportunity of briefly mentioning some experiments that I made on this mode of disinfection when in charge of the district laboratory at Aldershot.

The general plan of procedure was simplicity itself, and consisted in sowing, in various nutrient media, slips of shirts, blankets, etc., which had been soaked in sewage effluent and afterwards dipped into boiling water. The results that I arrived at are as follows:

If the blankets are lowered gradually into the water, and the disinfected portions are withdrawn before others are immersed, ten seconds is ample time to effect disinfection. Great-coats also should have the same period and mode of immersion as blankets, but five seconds, or even momentary immersion, is sufficient in the case of shirts, socks, khaki jackets, or trousers. I have carried out this plan in the field, and although it is certainly tiresome—at any rate, as far as bulky articles are concerned—yet, with a little good-will, it admits of a wide field of applicability. It is well known that woollen articles are damaged by boiling, but the periods of immersion named above had, apparently, no mischievous effect. Spores were unaffected; but, in the case of diseases common on service, this need not be a matter of consequence.

The Japanese use a portable field sterilizer, which, it is stated, is 'large enough to disinfect twenty blankets at a time.'* Portable steam disinfectors with all mobile units would be rather a council of perfection.

* 'Under the Care of the Japanese War Office,' by Ethel McCaul, R.N.C.

5. Disinfection of Eating and Drinking Utensils.

This is a very difficult matter, as the circumstances under which men in field hospitals are placed render a common use of these articles a constant occurrence. No plan is likely to be perfectly successful, even when coupled with the exercise of all possible supervision, and with warnings of the dangers which accompany such acts. Of course, all these articles ought to be constantly and carefully washed, and frequently dipped into boiling water.

6. Disinfection of Attendants.

In the field this can only be carried out, or, rather, attempted, by such personal cleanliness as may be possible under the circumstances of the case.

7. Disinfection of Stretchers.

When possible, separate stretchers should be reserved for infectious cases. The canvas should be well scrubbed, after use, with carbolic lotion, izal, or other antiseptic, and exposed to the air and sunlight for as long as possible. The germicidal power of sunlight is not always fully appreciated.

Whatever plans of isolation or disinfection are adopted in the field should never be considered as other than makeshifts, and, as a general rule, makeshifts of a very poor character.

A way out of the difficulty is suggested in the next section.

Removal of Cases of Communicable Disease.

If during the South African campaign the accommodation originally provided in general and station hospitals was satisfactory as regards material and sufficient as regards number, if the field medical establishments were adapted to meet the purposes for which they were originally designed, and if the administrative and professional skill were such as to call for unstinted praise from those best qualified to speak, it appears, at first sight, inexplicable that any cause for hostile

criticism could possibly have arisen in connection with the medical arrangements, or that our casualties from disease should have reached such an appalling figure. A reasonable explanation is easily forthcoming. Up to the present the officers of the medical department have not enjoyed control of the transport necessary for the carriage of the sick and wounded. The sick from the field hospitals at Spearman's Plain, and Trichard's, and Potgeiter's Drifts, were largely sent down country in the early days of 1900, in empty supply-waggons. The fighting line was spread over a wide extent of country, and the average distance to the railway from any part of the force must have been about thirty-five miles. There were three bad drifts to be crossed, and the so-called road consisted only of waggon-tracks. Oxen will not trek much more than twenty miles a day, and a two hours' outspan at mid-day is necessary to keep them in health. Keeping these facts in view, it was only natural that the supply department should have sent their waggons down country as seldom as possible, a circumstance which, unfortunately, was not in accordance with the interests of the medical services. That the sick should have accumulated under such conditions is not surprising. The greater the accumulation, the greater was the danger of the spread of disease, the greater the difficulty of removal, and the greater the strain on the base and stationary hospitals. Once the vicious circle was started, it was almost impossible to escape from its consequences. The sickness at the front taxed the accommodation at the base, and this circumstance reacted in turn on the field hospitals by rendering necessary the retention of cases which, in the interests of the whole force, clearly called for early removal to fully-equipped establishments. The risk of such a state of affairs to any force is plain enough.

Had the necessary transport been at hand, the earlier cases of fever, dysentery, and diarrhœa would, without any doubt whatever, have been moved at once, as the administration never looked at the field hospitals in any other light than as establishments for the collection, temporary treatment, and

despatch to the base, of the sick and wounded of the column. A certain number of trivial cases could very well have remained at the front, but this fact does not affect the main issue. To retain any cases likely to spread disease, under such conditions as those which are found in field hospitals, is directly conducive to an early arrival at the breaking strain of hospital administration; and it seems, on the face of it, scarcely just to deny to the medical department one of the primary means towards maintaining the physical efficiency for the care of which this branch of the service exists.

Mule transport would, without any difficulty, have insured, during the period referred to, the arrival at Frere of the sick and wounded on the day of their departure from the Tugela. Good mules will trek thirty miles comfortably in a day, so that there would have been no great difficulty in getting the transport back again at the front in a reasonable time.

Circumstances alter cases, and it is impossible for any administrator to lay down rules which are likely to meet all the exigencies of field service. This, however, does not in the least vitiate the broad principle that the medical department should be provided with the necessary means for removing, to other surroundings, all cases which are in the least likely to cause any kind of epidemic disorder amongst troops in the field. It may also be added that, although such cases, if retained at the front, should certainly be provided with every procurable comfort, nevertheless, the very existence of these comforts is apt to produce an altogether illusory appearance of efficiency, and so to distract attention from what is essential.

Before leaving this branch of the subject, I may mention briefly certain personal experiences of my own.

I was fortunate enough during the latter stages of the war to be able to effect the removal of sick from two field hospitals of which I had charge, at different times, without reference to anyone except the medical officer commanding the hospital to which the men were transferred. No precise rules were adopted, each case being judged on its own merits; and with the help of loyal and capable colleagues I do not think that

many mistakes were made. Of course, it is annoying for a medical officer in charge of a big hospital to have his beds filled with trivial cases, and a certain number of such were doubtless sent in. This naturally could not be helped, and the difficulty of early diagnosis was fully and generously allowed for by those with whom I was acting. Febrile cases, particularly those suffering from diarrhœa, were generally removed at once. These cases composed the majority of the sick, so that the plan rather suggested that of the French military surgeon of classic fiction, whose guiding principle of duty was 'de se débarrasser à tout prix de ses malades.' In spite of its drawbacks the plan answered well, and it had, if preceding statements are in any degree true, the ultimate effect of avoiding a far greater influx of sick, on the general hospital, than that which actually took place. I must admit that I was never able to put the results of my procedure to the test of prolonged experience; but, as far as I am able to form an opinion from the comparatively limited time during which this scheme was in operation, the general effects, as judged by the health of the men, were all that could have been desired. In the cases which I referred to above, no administrative difficulties occurred; a telegram informed me whether cases could be received or not, and arrangements were made accordingly.

There does not appear to be any valid reason why such methods should not be made generally applicable. To do so would mean increase of transport, but it would also mean increase of efficiency. The man in immediate charge of the sick is naturally the best judge of the time for removal, and he should, provided that military exigencies (such as provision of suitable escort in a savage country) permit, be allowed to act in a manner consistent with the dictates of his common sense.

Apart from all previous considerations, there must often be extreme danger of the spread of disease from the field hospital to effective troops. I have myself seen a field hospital placed between two line battalions, and not fifteen yards distant from either of them. These troops would probably have

been much safer if camped outside the walls of a hospital for infectious diseases. One of the battalions was moved after a few days, but its place was taken by a small-arm ammunition column. Service exigencies often necessitate an arrangement of this kind, and if a field hospital contained no infectious cases, the danger would naturally disappear.

Recapitulation.

1. That the existence of field medical establishments containing men under treatment for such diseases as enteric fever and dysentery, in the immediate neighbourhood of effective troops, is a direct and serious danger to the success of a field force and consequently to the safety of the State.

2. That measures of isolation and disinfection in the field, although not to be omitted, are not to be relied on.

3. That the limitation of the spread of disease in the field resolves itself largely into the prompt removal, to fully-equipped hospitals, of all cases of a communicable nature.

4. That the means for removal should be entirely at the disposal of the medical authorities, and that for this purpose the latter should be furnished with their own transport.

CHAPTER XXV

SICK TRANSPORT

In the previous chapter mention has been made of the desirability of placing sick transport in the hands of the medical authorities, for the purpose of insuring the rapid removal of cases of communicable disease from the neighbourhood of effective troops. There are other cogent reasons besides the one already given why the medical department should be granted, if not complete, at any rate partial autonomy in connection with the discharge of this particular service. At present sick transport remains as a matter of routine under the control of the Army Service Corps, although, on service, regimental transport is often used for the purpose. Under ordinary circumstances, whenever sick require removal, application has to be made to the Army Service Corps for the necessary means, and horses and waggons return to their own lines when the duty is completed. Suppose, for instance, that it is a matter of urgent necessity to remove a man, on account of the nature of his malady, from one hospital to another within the limits of the same station—the first thing to be done is to make out an application, signed by a medical officer, for the necessary transport, and until the latter arrives the man has to remain where he is. There is no doubt that ambulances are sent with the most perfect promptitude, and it is almost needless to state that there is not the faintest intention to convey, by the present remarks, any suggestion of a reflection on the branch of the army by which these services are carried out. But unquestioned efficiency does not affect the general principle that it would be well to avoid

the risk of possible delay through the miscarriage of messages, or through other causes which the present system entails; and when the transport is called for—as is sometimes the case—late at night, when offices are closed, deplorable consequences may possibly result.

As far as my own experience allows me to form an opinion, the system is fraught with inconvenience of the most exasperating kind. An instance of what actually occurred may make this matter clear. During the manœuvres of the 1st and 2nd Army Corps, 1903, I was placed in medical charge of a brigade of field-guns belonging to the Aldershot force. The sick transport was in charge of civilian drivers, and on the first day of operations the ambulance arrived over half an hour late, and only a few moments before the batteries filed out of barracks; during the twelve days that the manœuvres lasted, I only remember one single occasion on which it appeared in proper time; on the third day it arrived nearly half an hour after the unit had started, and on receiving instructions to 'pick up the batteries as soon as possible,' the driver complied with an alacrity which disorganized the formation of an infantry brigade, besides causing serious danger to the men; and on the day of the last engagement it arrived so long after the batteries had disappeared that the driver was unable to rejoin them until after arrival in camp. The night before our return to Aldershot, the time of departure for the following day was changed at a late hour, and it was with great difficulty that the driver was found and the necessary order communicated to him. All this annoyance and danger would have been avoided by placing the transport absolutely in the charge of the medical officer, and having the horses picketed with those of the unit with which he was doing duty. The driver might also have been attached for rations, and so have avoided the necessity of his leaving the lines. As things are arranged at present, drivers and transport go to their own lines at night, and if any alterations in the programme of the unit occurs after their departure, there is some chance that

the new order may fail to come to hand. Of course, it must not be forgotten that in these instances civilian drivers were employed, and that the men, not being under discipline, showed an amount of indifference that would have been impossible in the case of soldiers. But even when the latter are in charge of waggons mistakes occur, owing to the simple fact that the sick transport of any given unit being, perhaps, a mile away, a number of contingencies are opened up in the shape of non-delivery of messages, or even, as I have known, of failure on the part of drivers to find their destination, as it is quite an easy matter for even an intelligent man to get hopelessly out of his bearings in the midst of a large body of mixed troops.

These statements may appear trivial, and irrelevant to the general question of health, but experience shows that they are neither one nor the other; and the fact of a unit, more particularly a mounted one, being left without carriage for cases of serious illness or accident may mean startling consequences, and this distinct from official complications, which are in themselves sufficiently grave. On service the control of transport by the medical department is naturally far more important than in peace. I remember, when in charge of a convoy of wounded in South Africa in 1901, that the conductor coolly suggested leaving me thirty miles from my destination, on the ground that he thought the transport might be wanted for other purposes and that he had no orders to proceed beyond the point where he proposed to stop, and where there was only a remote chance of obtaining either oxen, mules, or waggons. Only a verbal arrangement had been made, as the circumstances of the case did not admit of any other; but I naturally saw no reason to alter the programme on account of a statement which I thoroughly disbelieved, and I was careful, on the earliest possible opportunity, to communicate the occurrence to the man's commanding officer. The incident may not seem worth recording, except in so far as it serves to illustrate the principle that there should be no chance whatever of such a possible misunderstanding as that which has just been

mentioned. If the man, instead of being a complete stranger to me, had been habitually under my control, he never would have ventured to make proposals framed with a view to his own personal convenience, and entirely opposed to the efficient discharge of duty.

Another source of annoyance is the constant changing of animals or of drivers. I have had mules handed over to me in such a wretched condition as to break down after a few hours' trek, leaving me stranded, on the veldt, miles from my destination, and with a very doubtful prospect of ever reaching it with my charge complete. It seems only fair, if the medical authorities are held responsible for the satisfactory performance, taken as a whole, of the services connected with the sick, that the first named should not suffer in reputation, or otherwise, if certain of the means provided for the execution of their duty are not entirely what they should be. Although, no doubt, the medical officer would never be considered accountable for the condition of the transport animals of a sick convoy, on the other hand, evil consequences, arising from this source, must ultimately reflect on the medical department by lowering the general standard of results.

Surgeon-General Wilson's evidence in connection with sick transport, as given before the Royal Commission on the war in South Africa, clearly shows the disadvantages of the present system.*

* 'Question 3,743. . . . The only medical unit for the Colonial troops at first was the New South Wales contingent, who brought half a field hospital. . . .

'I told them to telegraph for the other half, and they brought it. The officers were thoroughly efficient, and they had one great pull over everyone else, and that is they brought their own transport with them. . . . Their transport was the thing for us to imitate. It was very good ; they had their own horses, which were never taken from them. We simply got whatever we could. It was taken away from us and given to us, and we just got what was left. . . . On the advance to Kroonstad, the New South Wales Field Hospital was the first in the field to the relief of the men, because they had their own transport ; they had their own horses, and that was the great thing.

'Question 3,750. Why should not you have your own horses ?—Of

There is another view of this question, which, I believe, has never yet been discussed, and this is whether the use of supply-waggons for the transport of the sick and wounded is in accordance with the spirit of the Geneva Convention. Waggons sent down country for supplies are clearly on a hostile errand, and to utilize this means of carriage for the removal of patients would appear to subject the latter to the risk of being left on the road if the transport were seized by the enemy. If, on the other hand, exemption from capture were claimed on the ground of the protection afforded by the Geneva Cross, it might be argued that to send what is for the time being an ambulance, whether structurally so or not, on a service designed for the furtherance of hostilities is a violation of the spirit, if not of the actual letter, of the Convention.

The above, in common with other dubious points, might be cleared up with advantage. If the transport were in the hands of the medical department the question of neutrality could not possibly arise.

In Canada the medical service has entire charge of its own

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course, transport is always the difficulty. . . . The General wants food for his men, and he would want a very large establishment of transport if we could keep our horses and mules as we ought to keep them. I quite see his point, but until we do get our own regular, steady, trained horses, we will never be efficient, and able to move like the New South Wales Hospital, who had theirs.

'Question 3,752. Do you think economy is a matter which ought to come into consideration in a case of this sort?—No; but, still, although there was no economy in South Africa, we could not do it, as the animals were dying by thousands.

'Question 3,753. How do you account for the New South Wales unit being able to keep their horses apparently in good condition?—They were with them, and had the same men caring for them, whereas the other transport was under any drivers. They brought their own horses in the ship with them, and always watched them, and took more care of them than any ordinary driver picked up anywhere would.

'Question 3,755. Surely, if that could be arranged in New South Wales, it could be arranged here also?—If it could, we would have a very different story to tell' (evidence of Surgeon-General Wilson before the Royal Commission on the South African War).

transport. The drivers are all trained orderlies, and in South Africa the scheme is stated to have worked admirably. The waggons were designed by Colonel J. L. Neilson, late Director-General of the Medical Services of Canada. If autonomy for the medical department is found consistent with excellent results in Canada, it is not immediately evident why it should not apply equally well in the United Kingdom. At the eleventh annual meeting of the Association of Military Surgeons of the United States, Colonel Neilson delivered a highly practical address on the work of the 10th Canadian Field Hospital in South Africa. The address, which is well worth studying, can be found in the journal of the Association, and it derives additional value from the excellent illustrations which accompany it.

In connection with the above hospital, the following passages from Surgeon-General Wilson's report on the medical arrangements in the South African War are of striking interest as affecting the subject of sick transport:

'Its most obvious advantages are as follows:

'1. Its transport waggons are convertible into ambulances, so that while stationary it still retains the means of evacuating its sick and becoming mobile.

* * * * *

'The Canadian Field Hospital was fitted out in Canada, *especially as a field hospital having its own transport*, consisting of ten waggons, nine of which were convertible into ambulances. It is hardly possible to conceive a field hospital constructed on better lines than these, and the Committee strongly recommend its adoption.' *

To give full power to the medical department in the matter of transport, it would be necessary to develop a new section of the R.A.M.C. A certain number of men would have to be

* Report of a Committee appointed to consider the organization and equipment of field medical units, comprised in the Report on the Medical Arrangements in the South African War by Surgeon-General Sir W. D. Wilson, K.C.M.G., pp. 88, 89.

A detailed description of the Canadian ambulances is to be found at p. 352, Appendix xviii., of Sir William Wilson's report, above referred to.

enlisted as drivers, and put through a thorough course of riding, driving, shoeing, and, in short, of every detail of work which would bear on the efficiency of the transport of which they would have charge. The instruction could very well be imparted at Aldershot in the school of the Army Service Corps, and in view of the results attained by that branch of the service in the case of their own men, there is every reason to believe that a similar excellence would not fail to accrue in the case of the men of the R.A.M.C. As many men as possible, besides those specially enlisted, should be allowed to go through the course, and a due proportion of those who qualify should be sent to the larger stations, where their services would be likely to be required. There is no reason to anticipate that men employed in this way would lose efficiency as sick attendants. It would be just as reasonable to doubt the skill of a medical man because he happened to excel in some other kind of knowledge besides that belonging to his own calling. As above mentioned, the drivers of the Canadian transport are all trained orderlies, and results seem to have proved the wisdom of this arrangement (see p. 490).

Although it might be impossible to combine both duties at the same time, the men employed as transport drivers could be called up periodically for training in general corps work, in addition to the usual recruits' course. At Aldershot and other large stations sick transport might be exclusively in the hands of medical authorities, but in small stations where ambulances are seldom required there would be no particular reason for departing from the present system. On taking the field, Principal Medical Officers could allot the sick transport as they thought fit, and there would then be no question as to its being on hand when required. This scheme need not interfere with the employment of native drivers; the latter were absolutely necessary in South Africa. In the case of isolated parties these proposals need not come into force. The scheme would naturally have to be applied in accordance with the dictates of common sense and the requirements of the campaign. To lay down any detailed plan would be impossible, and the above is therefore only intended as the

bare suggestion of a departure which would require the co-operation of officers of more than one branch of the service before it could assume anything like a tangible form. Perhaps it would be well to explain that in speaking of sick transport it is not meant to include the ambulances of field establishments. These carriages belong exclusively to the fighting line; they are not intended to convey patients down the lines of communication and to the base.

In this connection Colonel Furse writes:

'Transport is intimately connected with the medical department of an army, for the removal of the wounded from the battle-field, the necessary dispersion of sick, and the provision of medicaments and appliances on which rest the saving of human life, depend on transport entirely. It will be urged against a separate transport that the medical pressure for transport is occasional, whereas with supplies it is constant, hence endowing the medical department with special transport must be detrimental to the economical working of the general transport of the army, *yet the importance of a separate transport for this department cannot be underrated.*

'The description of transport needed is special, and as the time for sick convoys to move depends on certain considerations which only medical officers can estimate correctly, it is difficult to tell when a pressure may arise. Who is to guarantee when the necessity appears that the commissariat officers, who are entrusted parties in the transport, may not consider the needs of their own service far to outweigh those of the medical department, thus giving rise to a difficulty which could not occur were a distinct transport affected to this department.'*

At present the R.A.M.C.(T.) controls its own transport. Training is systematic, and certificates of proficiency are required for promotion in the transport section. The syllabus of instruction is found in Appendix VI., Sub-Appendix VII., 'Regulations for the Territorial Force.'

* Report on the Medical Arrangements in the South African War, by Surgeon-General Sir W. D. Wilson, K.C.M.G., p. 107.

It would be quite out of place to attempt any comment on the manner in which the work is generally done; those who wish to satisfy themselves on this point can easily do so.

The ambulance used in our army is fairly well known, and its merits, therefore, need no special mention at present, but an incident illustrative of the opinion entertained by the men concerning this mode of conveyance, for suffering and helpless patients, is sufficiently instructing to be worth placing on record. Early in October, 1901, I was directed to proceed as Senior Medical Officer to Zululand, and it therefore became my duty to arrange for and superintend the removal from the front of the men who had been wounded in the action at Itala. An improvised hospital had been established at Nkhandlha, about 100 miles from the nearest railway, at Tugela. The fighting on both sides had been of the most determined character, and many of the wounded had received injuries of extreme severity. After consultation with the medical officer of the force which had been engaged, it was decided to move the wounded at once to the base. The surroundings were certainly not well adapted for successful treatment, and it may here be stated that the splendid surgical results achieved in the force of exceptional difficulty were due to the professional skill of a medical officer whose courage on the field and devotion to duty reflect the highest honour on his corps. The transport consisted partly of trek waggons—which were, of course, springless, and were certainly not built with a view to the ease of travellers—and partly of ambulances designed, it is needless to say, for the comfort and well-being of sick and wounded. The men who had received the severest injuries were, at their own request, placed in the trek waggons, while the men whose wounds were of a comparatively trivial nature volunteered to be conveyed in the ambulances. On the road I offered to make any change, consistently with their welfare, which the men desired, but the proposal only produced consternation amongst the sufferers. We covered sixty miles in the first two days, and crossed two of the worst drifts I have ever

seen, but the men stood the journey well, and no untoward consequences whatever could be set down to its effects.

Personally, I believe that the ambulance answers well on anything like level ground—a belief which is founded on my own experience as a patient—but that in very rough travelling the springs may throw the occupants about in a most dangerous manner. A trek waggon is naturally free from this defect, and if the shocks are well deadened with hay, straw, or the like—the more the better—it is a much more satisfactory means of sick conveyance than might be imagined.

One manifest objection to a trek waggon is the absence of cover. When conveying, in these waggons, sick or wounded who had lost their helmets, and who were thus exposed to a blazing sun, I provided pieces of lint which were worn on the head, and which were kept constantly wet with water poured from a water-bottle by an orderly. I found this plan thoroughly efficacious in warding off any evil effects from the exposure.

The Canadian ambulance designed by Colonel Neilson, to which reference has already been made, seems to have given great satisfaction. One great point in its favour is that it can be adapted for the transport of surgical and medical equipment as well as of patients, so that hospital supplies can be conveyed, as they should be, by waggons belonging to the medical department, and not by those of any other branch of the service.

In the *Journal of the R.A.M.C.* for June, 1904, there is an account of a galloping ambulance, the utility of which latter has been tested at several yeomanry trainings. It is designed by Surgeon-Lieutenant Avery, and, as far as can be judged at present, promises to fulfil what is greatly needed—viz., efficient means for the succour of the wounded of mounted troops. In the October number for 1904 of the above journal there is an excellently written account of this ambulance by Sergeant W. Merchant. The account is accompanied by two photographs which give a very good idea of Surgeon-Lieutenant Avery's invention.

Colonel Hathaway, A.M.S., who has great experience of medical work on service with mounted troops, has most kindly supplied me with his own proposals as to professional aid for these branches of the service.

With Colonel Hathaway's permission, I have included in this chapter an account of his scheme, including a description of his ambulance, and of an admirable device for conveying sick or wounded men in the saddle. As I was a member of the committee appointed to report on Colonel Hathaway's last-named design, I have every reason to grasp the excellent possibilities which it holds out.

At the last International Exhibition of Red Cross Appliances, Colonel Hathaway's ambulance was awarded the Empress Marie's prize of £300, and has since been put to a severe test during the manœuvres of 1909.

Colonel Hathaway's Proposals.

The means proposed by Colonel Hathaway are, in his own words, comprised in a 'saddle crutch,' which has, after trial and report by Royal Artillery and cavalry, British and Indian, been adopted by the Government of India for all cavalry in that country. Two are carried by combatants in the ranks of each squadron, hanging from a saddle D on the off side, and also strapped to the surcingle. When the crutch is required for use, it is unstrapped from the saddle D, and the bag remains on the saddle, small splints, bandages, etc., being carried in this bag.

The crutch consists of a semicircle of light metal, padded inside, and leather-covered. It has two large D's at its front extremities, and a metal, leather-covered upright fixed by a hinge at right angles to the middle of the semicircle behind. When the wounded man has been assisted to his saddle, the upright is placed in the crupper D; it keeps the support at the right height on the wounded man's back, and prevents lateral swaying.

A strap is threaded through the two D's in front, and through the fans of the midarch of saddle. If he wishes to dismount without assistance, he unbuckles the straps. If he

becomes unconscious whilst in the support of the crutch, he cannot fall out of the saddle.

In the construction of this support the type of a comfortable upright chair is taken, because it is better both for a man and the animal that he rides that he should maintain, as far as possible, the normal position in the saddle. If he reclines, his legs cannot be comfortably kept down in the stirrups, but must be raised towards the animal's withers in

FIG. 57.—COLONEL HATHAWAY'S SADDLE CRUTCH FOR SICK OR WOUNDED.

inverse proportion to the descent of his back; this makes the rider insecure, and upsets the balance on the animal. The whole of the weight being on the top of the back instead of being distributed down the sides of the saddle, the girth difficulty is much increased.

Let us now consider the arrangements for large bodies of mounted troops. For these light-wheeled vehicles must be available, proceeding as fast as the units they are serving

when empty, and going anywhere and over all obstacles that the guns of the Horse Artillery can negotiate. Strong wheels and springs are required for such work, and the weight must be well within the power of the animals pulling, under all circumstances.

These vehicles should move in rear, keeping as close a touch with the troops as can be managed in safety.

There should be a mounted detachment of three bearers with vehicle. When fighting takes place, these bearers ride forward, carrying one light cavalry stretcher.

They join the troops in action and dismount. One of the three holds the horses, whilst the other two men prepare their stretcher and assist the bandsmen of the regiment to render first aid and apply field dressing.

Two of them carry the wounded back to the ambulance, which is halted as near as possible, their horses being led along with them by the third man.

After placing the man in the vehicle, they remount and return to the fighting-line at the gallop if necessary.

It is an essential part of my system that to save time there shall be but one journey of the bearers from the front to the rear, instead of from the rear to the front and back again, for each patient. . . .

A light-wheeled ambulance is by far the most important part of any improved system for disposing of the wounded cavalry. . . .

Many surgeons in South Africa, including myself, saw most useful work done by the Indian tongas, so I adopted the tonga to the superstructure of my waggon, and removed two great faults noticed in South Africa—namely, the body of the vehicle being close to the ground, and the small number of recumbent cases that it was possible to carry in one vehicle.

There was also another trouble—'sore bellies' and 'sore backs' of ponies—but this was caused by difficulty of balance, the Indian tonga having been originally constructed for sitting accommodation.

My tonga carries four men lying down. There is no

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sitting accommodation, but surely the lying-down accommodation is generally far more useful, and it does no harm for men who could sit up to lie down for a time.

The result of trials with the waggon of the same superstructure was that, when three other medical officers and myself lay down in both vehicles, and were drawn quickly over rough ground, we unanimously agreed that transit in the tonga was unquestionably more comfortable.

The reason is this: that a strong spring attaching the

FIG. 58.—COLONEL HATHAWAY'S AMBULANCE: SIDE VIEW.

curricle harness to the pole at one end with the springs on the axle at the other end are far less 'dead' than the springs on two axles only in the four-wheeled waggon. Up to this careful trial I have always been in favour of four-wheeled vehicles for carrying wounded, but now I have changed my opinion completely.

Another advantage of a two-wheeled vehicle is that obstacles are more easily avoided by two wheels than by four, or if negotiated, there is only one bump to the patient instead of two in a four-wheeled vehicle.

There is the disadvantage that both animals might fall in

a two-wheeled vehicle, but the drop of the pole would not be much, because the curricle saddle and the animal would keep it from the ground, so the occupants of the stretchers in the tonga would not be seriously inconvenienced.

There are third-class wheels and arms interchangeable, of course, with third-class wheels of other transport.

Indiarubber tyres could be used until they wore out. The superstructure is composed of angle and T iron; the stretchers are run in by two men. One man goes round to

FIG. 59.—COLONEL HATHAWAY'S AMBULANCE: BACK VIEW.

the front of the tonga, and the cross-bars are opened, this sets free one of each of the bearer's hands, which is used to turn the cross-bar back and lock it. There is a bolt which drops and prevents the cross-bar jumping out of its socket, and there is a strong hinge on the other side of the cross-bar.

Four recumbent cases are carried comfortably in this vehicle.

They are near together, it is true, but there is room for men to turn on their sides on each stretcher, and plenty of

air is obtainable from the sides. Moreover, patients would not, as a rule, remain long in these tongas, which are only used as a rapid means of conveyance from the front.

The men's rifles are carried in racks above the stretcher, and their kits go in the lockers underneath the waggon. There are four of these lockers, and the medical and surgical equipment is also carried in them, together with two tent side-walls, which can be laced on to the side-curtains of the cart, so as to form tentage for twelve when required for bivouac.

The plan of attaching tentage to general service waggons for covering troops at night would cause a great saving of time and labour. In formation of camp the waggons would halt at sufficient intervals to allow their canvas to be let down and pegged to the ground.

This canvas could be attached to the eaves of the waggon on each side, whilst a separate covering would be provided for the stores in the waggon, so that they could be got at at any time without disturbing the tentage.

The length of a general service waggon is 11 feet 4 inches, and the canvas sides would be made wide enough to cover a man lying at right angles to the waggon. Five men could be covered on each side of the waggon. The eaves are 5 feet from the ground, so there would be plenty of air-space.

The width of a waggon is 3 feet 9 inches and length 11 feet 4 inches, and two more men could sleep underneath, so that twelve men would be accommodated by each general service waggon without in any way interfering with the contents carried.

The weight is 10 cwt. unloaded, and 11½ cwt. loaded with stretchers, tent, and medical equipment.

The horses of the three mounted bearers which accompany it would be fitted with breast harness, so that two of them could assist to draw the tonga when loaded with four patients, or when required by the nature of the roads or the distance to be travelled.

A good draught-horse should draw a weight of about 1,500 pounds about twenty-five miles per day, walk about three miles per hour, and trot at the average rate of six miles.

My tonga loaded with all kit from four patients, their

equipment and rifles, and the driver would weigh under 2,284 pounds, so that it would, for all ordinary work, be well within the scope of a pair of horses each capable of pulling 1,500 pounds.

The measurements of the tonga are as follows: Extreme length from end of pole to back of tonga, 13 feet, so that the vehicle would take up little room in a column—a great consideration. The length of the body is $7\frac{1}{2}$ feet, height 7 feet, width of body 5 feet; width, including wheels, 7 feet. Height of body from ground, 2 feet, so it would clear obstacles easily. Height of lower stretcher platform from the ground, 3 feet: this is the height the stretchers would have to be raised by bearers from the ground to place in the tonga.

Size of lockers, 3 feet long, 2 feet wide, and 1 foot high. Wheels, 4 feet in diameter.

I propose to find the mounted bearers without adding to the personnel or horses of the present ambulance for cavalry. The cavalry field ambulance for fifty patients is intended to succour one mounted brigade which has a total personnel of 2,439, while four cavalry field ambulances are told off to a cavalry division, which has a total of 9,503 of all ranks (see p. 470).

There are 6 six-horsed ambulance waggons and 4 two-horsed ambulance waggons; total, 44 draught-horses and 22 drivers.

For my system there would be 6 of my two-horsed tongas and 2 six-horsed ambulance waggons—*i.e.*, 24 horses and 12 drivers, a saving of 20 horses.

With these 20 horses I propose to mount 20 men of the bearer division, and distribute them as follows: 3 to each of the tongas, which accounts for 18.

The two other horses would be given to the buglers, who, if mounted, would be most useful, taking messages and holding or leading away horses. They could also be trained in signalling, and take messages with regard to purely ambulance requirements from the front, and transmit them to the Tent Section.

This would leave 20 rank and file in the bearer division unmounted: 2 would be employed as waggon orderlies of

the 2 six-horsed ambulance waggons; the remaining 18 could join the Tent Division of the Cavalry Field Ambulance for general duty.

Twelve drivers of the Army Service Corps would not be required under this modification.

The personnel and ambulance of the Cavalry Field Ambulance must have been carefully considered, and I would not presume to suggest any alteration, excepting that which is, in my opinion, absolutely necessary for efficiency—viz., that the bearer division should be mounted; and this I have demonstrated how to arrange, without any addition to the number of horses used by the Cavalry Field Ambulance.

Let me, in conclusion, briefly summarize my proposals. They are three in number:

Firstly, I propose an ambulance which starts to work from the front, as the bearers, being mounted, can keep as near the front as required.

Secondly, I propose to give cavalry ambulance transport which can move at the same speed and over the same ground as the mounted troops.

And, lastly, I propose to supply a mobile hospital on wheels, for each tonga is capable of carrying four lying-down cases and tenting twelve cases when stationary at night.

Should it be necessary to leave seriously wounded cases behind in a rapid advance, my tonga is self-contained, and becomes a twelve-bedded hospital, which, when cleared, can rapidly rejoin its unit.

The above advantages are obtained, with a considerable reduction of personnel, without any increase in the number of horses or the carrying power or strength of the waggons.

Having had experience with mounted troops in the field, I am, to some extent, in a position to appreciate the value of Colonel Hathaway's scheme. Ambulances capable of such work as that described above, and placed under the control of the medical authorities, would, if provided in sufficient numbers, go far to remove the deadly danger caused by the accumulation of sick in the immediate neighbourhood of the fighting force.

CHAPTER XXVI

ROUTINE DUTIES

ALTHOUGH the duties of the medical department are clearly laid down in the Standing Orders R.A.M.C., Regulations for Medical Services, and King's Regulations, the successful interpretation of these duties is really a matter of experience, and without this experience a variety of official pitfalls endanger the path of the recently-joined officer. Take, for instance, the case of a medical officer of a few months' standing placed in charge of a brigade at a big station. It is perfectly true that his duties, as far as hours go, are not harassing—in fact, if he is not employed at the military hospital he is likely to find the mornings hang heavy on his hands. His first duty in the day is to see the 'morning sick.' The work appears on the face of it simple enough, but in reality it is of a most gravely responsible nature.

Putting aside the question of possible injustice, failure to detect disease may be followed by consequences disastrous to the public service and, incidentally, to the individual. A slight sore throat, a cold in the head, or a headache may be the initial sign of scarlet fever, diphtheria, measles, or other acute specific ailment. It is a good rule to take the temperature and to examine for rash and sore throat every man in whom the nature of the disability is not at once apparent. There is one forensic principle which every medical officer should not only bear in mind, but the importance of which he should thoroughly grasp and never lose sight of—viz., the difficulty of proving a negative. It is an easy matter to say a man is suffering from some morbid condition, but it is a widely different thing to prove that such a condition is absent. This

rule, of course, does not apply to cases of palpable imposture, which should be readily detected, although, in my experience, imposture of any kind is almost non-existent. Cases, nevertheless, which present great difficulty occasionally arise, and in these it is always well, in accordance with the foregoing principles, to give the benefit of the doubt to the soldier. I remember an instance in particular in which a soldier of a native regiment persisted in asserting that a slight flesh wound of the front of the thigh absolutely incapacitated him from using the injured limb. It was perfectly clear to several medical officers who saw the man that he was an arrant impostor, but he had so long maintained his fraud that I have very little doubt that he actually believed himself to be a much injured individual, and the victim of a mixture of professional ignorance and brutality, a belief that was most firmly entertained by others besides himself. The slightest touch of the hand on the limb caused him—according to his statement—the most excruciating agony, and any attempt to move the knee was followed by heartrending shrieks, which were kept up without intermission until the victim ceased his efforts from want of breath.

His persistent deception received every possible encouragement from irresponsible friends; and the sympathy of the latter was not in the least affected by the circumstance that the sufferer occasionally limped on the wrong leg. Unfortunately, it was impossible to make use of this oversight, as evidence of fraud, and the man remained in bed 'under observation.' In the end complete detection and exposure were obtained. The man was inordinately vain of his experiences under fire, and while being encouraged to recount the history of the engagement in which he had been injured, and his attention being distracted from his wound, he allowed the affected limb to be pinched, handled, and squeezed, without the least appearance or suggestion of discomfort. This performance took place in the presence of numerous witnesses, whose evidence was quite sufficient to secure a conviction at the court-martial which followed. In this instance the original opinion of the medical authorities was vindicated, and the justice of their action fully admitted. The case is instruc-

tive as an example of the difficulties in which medical officers are frequently placed. It is true the disability had no immediate relationship with matters of general health, but the principle which it illustrates—viz., the value of exhaustive examination—is one which should insure the medical officer against the risk of allowing men to return to their rooms, when actually unfit for duty; or, on the other hand, of becoming the victim of an impudent rogue. No trouble is too great for the purpose of arriving at a just conclusion; to admit schemers into hospital, through failure to examine with care, is a direct encouragement to fraud and inefficiency, while the opposite error may result in wrecking the reputation of the individual and bringing discredit on his corps, and this apart from possible effects on health generally. The injustice to the sick is too evident to need comment.

It is a sound point to remember that soldiers are notoriously prone to give the answer that they think is expected, so that in examining men leading questions should be avoided, except when there is no other reasonable way of eliciting information.

Doubtful cases can be detained up to two days, and this is a far better plan than giving such men medicine only, or marking them 'light duty.' Even if a man has no objective signs of disease, it is usually unwise to send him away. Detention is an authorized measure, and causes no inconvenience. More than one case has occurred of men who have reported sick in the morning with headache, pains in the limbs, loss of appetite, or slight nausea, and who, being detained for the day and the temperature taken in the evening, have been found to be in the earlier stages of some acute specific disease, and this in spite of the fact that the thermometer at the hour of the morning sick parade had shown no rise, and that pulse and respiration were equally devoid of suspicious changes from the normal.

Inspection of Barracks.

This is often looked on as an especially irksome duty, and is commonly believed to be tacitly resented by officers commanding units. Speaking for myself, I have never received anything but courtesy and assistance in the discharge of this

work, and if my presence caused annoyance any suspicion of such a thing was carefully concealed from me; but at the same time it is only natural that a commanding officer may feel some slight irritation at the official expression of views concerning the internal economy of his unit, emanating from an officer very far junior to himself both in years and in the service. Injudicious recommendations are not the fault of the recently-joined officer—from whom they usually proceed—but are the result of unavoidable inexperience. What is really required can usually be learned without much difficulty. A notebook containing the names of the places to be visited is a great help, each place being ticked off after inspection, and any defects noted in writing. The following list comprises the principal parts of barracks which should be visited:

Guard-rooms.—Note general state of cleanliness, particularly the detention room and the urinal attached. Inquire as to the nature of covering allowed to the men on duty, and to those under detention. It may be necessary to recommend extra blankets. Examine guard-bed, where it is still found in existence. There is often an accumulation of dirt between the wood and the iron framework, and vermin are occasionally present. The new-pattern guard-beds are fixed by their heads to the wall; they are often placed too near each other, and this arrangement might prove a serious danger in the case of a man suffering from pulmonary tuberculosis with expectoration. Note means of ventilation, and if the ventilators are in good order or otherwise. Inquire as to the means of ablution, and note particularly if the basins are sufficient in number. Note condition of latrine.

The dinners of the men on guard often present a singularly unappetizing appearance, being covered with congealed fat. In some units hot-water trays are provided. The latter are a great comfort to the men, and would probably be always obtained on the suggestion of a medical officer. In cases where the regimental police have replaced a guard, the men have dinner in the rooms.

Bread and Meat Stores.—Note general condition and

ventilation. Bread should not be kept in the same store as the meat (see p. 322).

Kitchens.—Inquire if the means of cooking are satisfactory, and whether the ranges are in good condition. Ascertain whether basins and towels are provided for cooks. This latter point is an important one, and is apt to be overlooked. The above articles usually have to be obtained regimentally. Examine the form showing nature of the food during the week. It is important that the food should be varied as much as possible. In India be sure that the sweepers do not enter the kitchen on any pretence, and that dusters are scalded in boiling water every night. Note means of ablution, and whether natives employed are clean as to person and clothing. Personally, I strongly believe that no native should wear in kitchen, bakery, or dairy, the same clothes which he possesses for ordinary use. The exit pipe from the sink of the Indian kitchen is never trapped—at least, I have never seen it trapped. Flies constantly invade the kitchen through it, and this should be prevented by wire gauze over the opening of entry.

Latrines and Urinals.—Note conditions of cleanliness, also whether there is any caking or deposit in the urinals. Creasote oil is now being used to prevent caking; it seems to answer well. The water-supply in urinals is often insufficient. Women's latrines are occasionally in a most filthy state, owing to the undeveloped ideas, regarding locality, of the children who use them.*

Regimental Workshops.—Note cleanliness and ventilation, and here as well as elsewhere do not omit to ask, 'Any complaints?'

Barrack-rooms.—Note means of ventilation and general cleanliness. Ascertain the number of men occupying each room, so as to guard carefully against overcrowding. The number allotted to each room should be shown on the door. Note number and position of lights, also whether ordinary gas-burners or otherwise.

* These latrines are in course of disappearance, as separate latrine accommodation for each family is now being introduced in married quarters.

Ablution-rooms.—General conditions to be noted. Baths are sometimes insufficient in number and badly lighted. Ascertain whether a satisfactory supply of hot water exists. Note the number of basins, and also whether the interiors are slimy. Sand is useful in removing sliminess. Contagious ophthalmia is likely to spread from dirty basins. Broken foot-racks should be noted, and replaced if badly damaged.

Canteen, Grocery Shops, and Coffee-rooms.—These are sometimes managed on the tenant system and sometimes on the regimental system. The tenant system entails a greater chance of the introduction of deleterious articles of consumption, besides the loss to the institution by the profits of the middleman. The medical officer should ascertain the principle on which the institute is carried on, and if the last-named arrangement is adopted, extra care should be taken in the examination of supplies.

Sausages sold in the grocery shop are particularly worthy of interest on the part of both regimental and medical officers. This fact was recently brought to my notice in a somewhat striking manner. Certain cases of violent colic, accompanied by vomiting and diarrhœa, occurring among troops of which I was, at the time, in charge, were attributed on reasonable grounds to the consumption of the above-named articles of diet which had been purchased, in the usual way, by some of the messes. One of the men stated that he thought that 'the sausages were a bit off'; but otherwise nothing was complained of in regard to taste or smell. The supplies were obtained on the tenant system, and some indignation was manifested by the representative of the contractor at the suggestion contained in a recommendation to the effect that the sale of sausages should be prohibited.

Samples were sent to the hospital for examination, when it was found that the skins, in some cases, were tightly distended with gas; that the reaction of the contents was invariably strongly acid; and that a sour smell could easily be detected. It is possible that these sausages were originally no worse than others; but that fermentation, favoured by hot weather, had taken place, before they reached their destination, rendering them quite unfit for food. The attacks

of sickness were fortunately not serious, and passed off completely in a few hours.

Sausages are occasionally a means of palming off stale bread-crumbs and semi-putrid offal on a credulous public, at an extortionate rate. They may, on the other hand, be above reproach in every respect; but as excellence is difficult to insure, the safest plan is to keep them out of public institutions, and to leave the risk of food-poisoning, in this direction, to individual choice.

Women's Wash-house.—See if gas is laid on, and inquire as to the sufficiency of water-supply and the means of drying.

Gymnasium.—See that the nature of the ventilation is suitable, and that the means provided are used; the amount of CO_2 produced by exercise makes this a point of great importance.

Schools should never be omitted from inspection. The average number of children and the dimensions of the schoolroom should be ascertained, in order to arrive at the cubic space allotted to each pupil. Dr. Newsholme is of opinion that 150 cubic feet of space, 15 square feet of floor-space, and 1,500 to 1,800 cubic feet of fresh air per head per hour, are about the ordinary requirements for each scholar. Examine urinals and latrines. 'Urinal accommodation to the extent of at least five places for every 100 children should be provided, and at least one water-closet seat for every fifteen girls or twenty-five boys. One of the modern types of trough-closet is a very suitable form of latrine for schools, but the flushing provision must be adequate and systematically regulated.'* Note the warming and ventilating arrangements. Cast-iron stoves are particularly objectionable. Ask if the supply of fuel is sufficient, and otherwise satisfactory. Note the general appearance of the children. It would be a sound measure if school-children were paraded for medical inspection as well as the men. Inquire if any scholars are absent from school, and if so, on what account. Note means of lighting and whether the children sit in their own light, or otherwise. Desks should be placed at right angles to the windows, and the light should come from the

* Parkes and Kenwood.

left, in order to avoid shadows. Metal cups are sometimes chained to the lavatory wall; this is a most objectionable arrangement from a health point of view, as it may be the means of spreading disease by infection from the mouth or lips. Adjustable desks are required for growing children; this is a point which may be overlooked. Walls painted a dark colour mean absorption of light, and consequent damage to eyesight. See that there is a sufficiency of pegs in cloak-room.

Married Quarters.—In inspecting married quarters inquire carefully into the health of the children. The actual treatment of disease, in large stations, rests in the hands of a specially-appointed officer; but this arrangement does not debar the medical officer in charge of troops from detecting early cases of sickness. Considering the circumstances under which the married families are placed, infectious disease, if it once occurs, is, unless detected early, almost certain to spread, so that the time spent by the medical officer in ascertaining the state of health of the occupants is far from wasted. Married quarters are often painted a dull terra-cotta; it is an abominable colour, as by absorbing light it must naturally act injuriously on health. The provision of baths in married quarters is greatly to be desired.

Inspection of the Men.—See that the shirts are open and sleeves rolled up. The feet should also be bare, and for this reason the inspection should be made in barrack-rooms, when possible. Look particularly for cutaneous disease, especially itch, and notice whether men's feet are clean or otherwise. Ascertain whether socks and shirts are duly washed, and how often they are changed.

If there are any matters which the medical officer considers to be in need of improvement, it is a good plan to see the adjutant personally; but many minor points can be dealt with by simply indicating the defect to the quartermaster, who should always be present on these occasions. The quartermaster-sergeant sometimes accompanies the medical officer, but it is far more satisfactory that the quartermaster should do so. If the matter is outside the quartermaster's province,

the adjutant will probably be able to do all that is necessary. By keeping in constant touch with the adjutant duties are usually placed on a pleasant footing, and official letter-writing and misunderstandings are avoided. The adjutant can also advise as to what matters should be brought to the notice of the commanding officer. A whole host of minor sanitary defects can be set right by a verbal recommendation, and if a commanding officer considers a letter necessary he will generally say so. Every rule has its exceptions, and there are many cases in which a medical officer cannot cover his responsibility without putting his views in writing. Sanitary diaries ought to be carefully kept, and all recommendations, whether verbal or otherwise, together with their results, should be fully recorded.

Hospital Duties.—Either before or after discharging his professional duties in a ward, the medical officer should make a general inspection, including annexes, as to cleanliness, ventilation, etc., not omitting the patients and their bedding. The space between the pillow and the mattress is often a storehouse for a varied assortment of articles—pipes, tobacco, cigarettes, money, belts, and watches being amongst the hidden treasures revealed by a drastic inspection. The bedclothes should be stripped off—when no danger to patients is involved—and the men's feet examined, and the fact that the linen worn by patients has been duly changed should be insured. Inquiry should be also made as to when the extras are brought into the ward. This is really an important matter, and is sometimes overlooked. Extras, such as malt liquors and puddings, should be served at the dinner-hour. In some hospitals the extras make their appearance during the afternoon, so that a patient who has consumed a steak shortly after mid-day may possibly be refreshed with a custard pudding about 3 p.m. Extras, in the way of liquor, disappear at once if left to the patients; and the orderly of each ward should be held responsible that such issues are consumed only at the times authorized by the medical officer. If this is not done, all sorts of irregularities may occur. A case has, I believe, been known

in which a patient succeeded in hoarding up the bottles of malt liquor which had been ordered for him until, in his judgment, the supply was sufficient to insure intoxication.

Before leaving the ward, find out if the men have any complaints. Inspect the orderly's bunk, and see that the medicines are under lock and key, also that the dressings are tidily put away in their allotted place.

Irregularities, of course, must be checked, and among men of whom a medical officer knows nothing it is impossible, at first sight, to discriminate between good and bad ; but a few days', or even a single day's, observation will be a fairly reliable guide concerning the general characteristics of new admissions, and if self-respecting men are treated as such, they will not be unappreciative of the consideration shown them. Personally, I have found soldiers, with not many exceptions, thoroughly grateful for kindness, and willing to listen to reason. Undoubtedly they are suspicious, but if once their confidence is gained good results follow, and in the absence of a spirit of trust, the difficulties which face the medical officer in the treatment of disease are materially increased.

Routine lectures on hygiene to officers and men are now regularly instituted, and, judging by the interest which is generally shown in the subject, the results should prove to be of the best.

Inspections and Camp Conservancy on Service.

There is at least one wide difference between routine duties of the above nature on service and in peace-time. During the latter the vigilance comprised in the usual inspection is generally sufficient to detect and deal with disease-producing conditions ; during war, on the other hand, the medical officer is confronted, as a rule, with the ever-present danger of epidemic sickness. Without adopting the views of a distinguished medical officer, who is credited with having held 'hourly inspections,' it is no excess of zeal to subject the lines to careful examination once, or even twice, daily. When in charge of a yeomanry column in the Orange

River Colony, towards the close of the South African War, I had the services of an officer who carried out a scrupulous daily inspection of the camp. This arrangement, as far as it went, was excellent, but the good it did was prejudiced by the fact that the officer was not detailed to accompany me, and sometimes carried his own ideas into effect without reference to my opinion.

It need scarcely be observed that this omission was in no way intended to be a slight to the medical department, and on representing to the commanding officer of the column that the inspections should be made jointly, but under my direction, the reason of the suggestion was at once appreciated, and the proposed arrangement put immediately into force. I mention this apparently trivial fact with the object of drawing attention to the excellence of the recently-introduced principle of giving medical officers control over a sanitary staff (see p. 198).

Being armed with an adequate staff, the medical officer, if dissatisfied with the execution of his directions, can immediately deal with the case as he may think proper, and will be under no obligation to report to an already harassed adjutant or commanding officer instances of failure to carry out suggested sanitary reforms. It is difficult invariably to fix responsibility on the actual delinquent, and as often as not he escapes altogether.

If the camp is too extensive to allow of a complete inspection on a single occasion, it is a good plan to inspect given parts daily, taking care never to omit an inspection, except for unavoidable reasons.

Even at the risk of possible restatement of matters found under other headings, it may be well to set forth the main points to which the medical officer should direct his attention. Circumstances, naturally, alter cases, and the same method of examination will not invariably apply.

Water-supply.—Inspect source and search for possible causes of contamination.

Note position of water-carts in camp. They should stand well away from horse lines or latrines. They should be

kept locked, and the covers should fit well. Notice condition of interiors. Ascertain any methods of purification in existence, and also means of distribution.

Kitchens.—Nature of rations. Means of disposal of refuse; burning is the best, but it should not be carried out near the kitchens when cooking is going on. Shallow burial also answers well, and it disposes of slop water in addition to scraps. Nature of fuel; this is more important than may appear at first sight. In one camp that I was in, during part of the South African campaign, the cooks used all kinds of refuse, and the flavour that this horrible practice imparted to the food was indescribably disgusting. It would be well if instruction in cooking on service formed part of the field training of both officers and men.

Latrines.—Note position and general care. It is a good plan to dig the trench a little wider at the bottom than at the top, so as to avoid fouling the sides. I have no particular faith in disinfecting-powders. It is most unlikely, even if they have the effect commonly attributed to them, that they can ever be brought into sufficiently intimate contact with the refuse to have any widely destructive effect on germ life. In one sense their use is to be recommended, as they are certainly object-lessons concerning the existence of danger, and, it may be added, they are to some extent deodorant.

If buckets are in use, which should always be the case when possible, a sufficiency of liquid carbolic acid with water should be kept in each. Water alone may be recommended. This is far better than dry earth, which makes a singularly disgusting mess, is usually swarming with flies, and scarcely ever effects the purpose for which it is intended. Insist on the establishment of urinals in suitable positions. Buckets are good receptacles, or, when these are not to be had, empty tins may be used. Paraffin tins answer well. In the absence of the above, shallow trenches will do all that is required. The danger of passing water everywhere and anywhere ought to be fully explained to officers and men.

Transport Lines.—See that the refuse of transport animals is carefully removed. I have reason to attribute a very serious outbreak of diarrhœa among the Kaffir boys at the Remount

Depot, Durban, to saturation of the ground with stable refuse.

Ablution.—Visit the places selected for bathing and washing clothes, and ascertain the frequency with which such acts are carried out. Washing of clothes is a matter apt to be neglected in the field, and it should be one of the duties of the medical officer to ascertain if proper arrangements exist for this service. Vermin quickly appear on the clothing

FIG. 60.—THE SUFFOLK REGIMENT IN CAMP, SOUTHERN COMMAND MANŒUVRES, 1909.

Photo by Captain R. B. Unwin, The Suffolk Regiment.

and on the persons of the men, so that medical inspections as to cleanliness should be made with a minuteness which is scarcely necessary under peace conditions.

Tents.—Note number of men in each tent, and general condition of cleanliness, particularly as to the removal of the débris of food. It is most desirable that food should be consumed outside of and some little distance away from the tents. As many of the men as possible should take their food together, so as to facilitate the clearing away of fragments by localizing whatever has to be dealt with (see Fig. 60).

See that the tents are struck whenever possible; rolling up the flies is only a very inefficient substitute for this measure.

Clothing and Equipment.—See that all the men are provided with cholera belts, and that they use them. Ascertain how many shirts and pairs of drawers and socks each man possesses. A man who has sold or otherwise got rid of any of his underclothing may go on wearing the same articles until he has infected himself, and those who have the misfortune to live in the same tent, with some kind of vermin. See that the men have the regulation flannel shirts, and that they have not exchanged them for cotton ones. This latter practice is not unknown. Examine the water-bottles, and see that they are scalded out occasionally with boiling water. Ascertain if there are any complaints in connection with boots. Soles fastened with screws are stated to be particularly hard and unpliable.

The Men.—Men should be inspected daily, when practicable, and in small numbers at a time. The inspection, as far as circumstances allow, should be an individual one. Never omit to ask, 'Any complaints?' and make the men thoroughly understand that those feeling in any way indisposed are to report sick at once. I believe, from experience, that the number who report sick without a cause, on service, is a negligible quantity. There is little or no fear of creating loafers. It cannot be too strongly insisted on that men with slight rises of temperature, especially when diarrhœa is coexistent, may be spreading disease broadcast throughout a camp. Non-commissioned officers should always give information of any such cases coming to their notice. Of course, it is essential to keep effective men in the fighting-line, but it is far better that a man with little or nothing the matter with him should pass to the base than that others, who are acting as wholesale disseminators of epidemic sickness, should be allowed to remain among their comrades, as the ultimate loss in the latter case may be irreparable. The spirit which prompts officers and men to continue at their duty when they are actually sick is difficult to censure; but when the possible consequence of such acts is fully explained, the question bears another aspect, and

failure on the part of sufferers to make known the existence of certain ailments should be regarded and dealt with as directly prejudicial to military success.

In conclusion, there are two rules of prime importance which must never be forgotten in regard to camp conservancy.

These rules are comprised, firstly, in a frequent change of camping-ground, and, secondly, in the avoidance of concentration. These measures are naturally applicable only as far as military exigencies allow.

With regard to the first-named rule, I have again and again noticed a rapid improvement in health when old camping-grounds were abandoned and fresh ones occupied. If soil pollution is connected with outbreaks of certain forms of sickness, the above is only what might reasonably be expected. I have observed this sequence of events too often to have any doubts as to cause and effect; and without taking personal knowledge into consideration, I have had the connection borne out by the statements of officers of various branches of the service, whose evidence, in view of their experience, is sufficient to convey conviction to any unprejudiced mind (see pp. 30 and 48).

As regards the effect of concentration, it is well known that in civil life there is a marked correspondence between death-rates and the number of persons per acre of inhabited ground. For instance, according to Dr. J. T. Macnamara, M.P., there are in Hampstead 34 persons to 1 acre, and in St. George's the Martyr, Southwark, there are 212. In Hampstead the death-rate is 13 per 1,000, and in St. George's over 30 per 1,000. The contrast between the two localities as regards expectation of life is, according to the same authority, most remarkable, and is stated to be as follows:

Age.	Hampstead.	Southwark.
At birth	50·8	46·5
10	53·3	45·0
20	44·2	36·4
30	35·5	28·6
40	27·5	21·9
50	20·3	16·2

There is no reason to doubt that, within certain common-sense limitations, the same general principles of sanitation apply alike to military and civil life, and the above figures, coming as they do from a well-known authority, are worth careful attention in the lesson they convey as to factors which make for the well-being or otherwise of troops on service. The contention as to the evil effects of concentration of troops is also fully borne out by actual experience. An instance in point is worth recording. It is that of the camp at Olivier's Hoek in the Drakensberg in the winter of 1901-1902 and the succeeding spring. The area occupied was exceptionally extensive, and the general health exceptionally good. It is, of course, illogical to attribute this fortunate circumstance to any special cause, unless the other causes which might exert an influence in a like direction are also considered. It is perfectly true that the water-supply was excellent, and general sanitation scrupulously carried out; but after fully allowing for all such influences, there remains the fact that camps equally favoured in the last-named respects, but occupying, by comparison, restricted areas, contrasted most unfavourably in the matter of health. I must, however, in fairness admit that one of the most concentrated camps of which I have ever had experience—viz., that at Tyger Kloof, Orange River Colony—was also one of the healthiest. I believe that it was only the exceptionally rigid system of sanitation which was maintained that nullified the evil effects which would have otherwise been attendant on the numbers present.

It is only common sense to expect that the greater the numbers occupying any given space the fouler that space will undoubtedly become, and the more general health will suffer.

The above general scheme, with common-sense modifications, is equally applicable to the usual conditions of peace.

Choice of a Camping-ground in Peace.

The principles which should guide us in the choice of a camping-ground in peace or war are identical, but in peace these principles can be applied in a manner which would be impossible in other conditions.

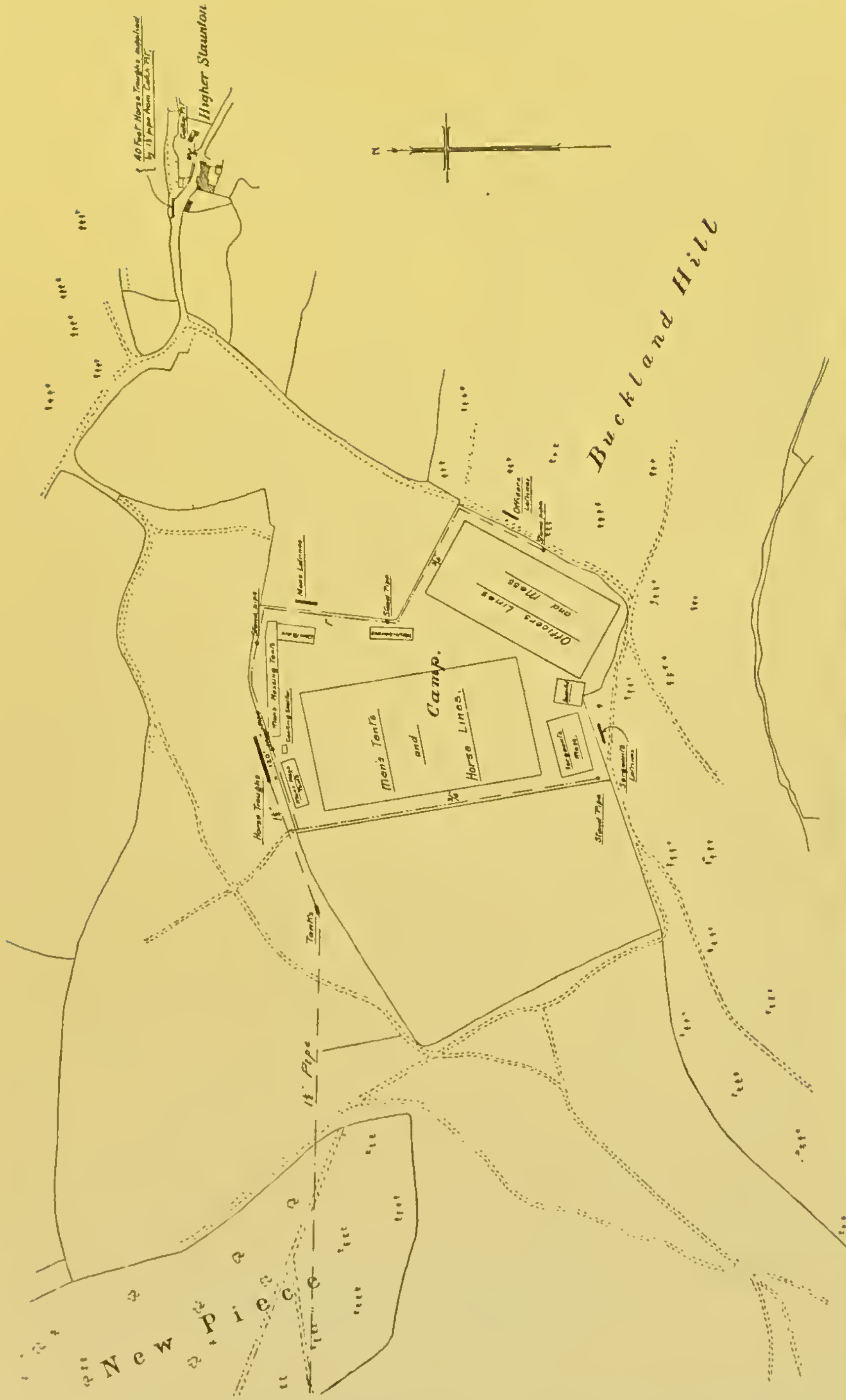

FIG. 61.—PLAN OF CAMP, WEST SOMERSET IMPERIAL YEOMANRY AT HOPCOTT, 1908.

The site should be on grass, if possible. One of the best soils is a sandy loam or a gravel, and one of the worst is a

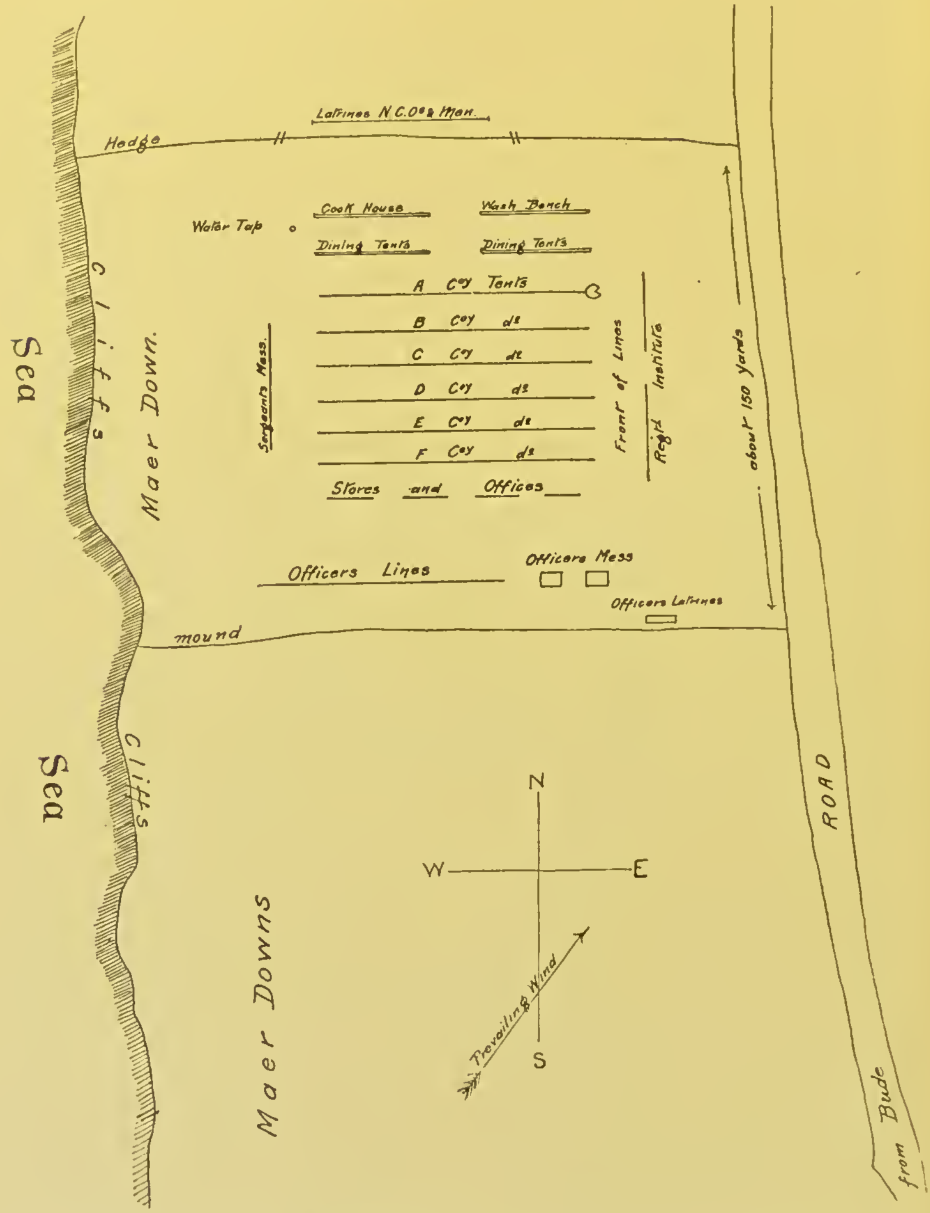

FIG. 62.—PLAN OF CAMP, DUKE OF CORNWALL'S LIGHT INFANTRY MILITIA, 1908.

stiff clay. The camp should face south-east, and the slope should be steep enough to insure reasonably good drainage. If the camp is in a field, ascertain if the latter is drained, and

if the drainage is satisfactory; in a park there will probably be no drainage. Ascertain if it is intended to dig latrine trenches or to use buckets. If the soil is a stiff clay, buckets should be used, and the same rule should apply to a less rigid extent in the case of sand, peat, or chalk. If trenches are to be used, be very careful that neighbouring water-supplies are not endangered. I have known a municipality enter a violent protest on this account only a few days before the opening of a yeomanry training, and this in spite of the fact that, from the official information sent by me to the Medical Officer of Health, the members must have been fully aware of our projected arrangements for several weeks. Fortunately, the difficulty was amicably adjusted.

Ascertain if water is to be carted or if a municipal supply is to be used; if the former, insure that the carts are thoroughly washed out, with boiling water if possible, before they come into use; if they can be steamed, so much the better. If possible, use the regulation cart with Slack and Brownlow filters. Examine the source, and if it is a spring, ascertain the yield from the R.E. officer detailed to be present at the inspection of the site. Remember that a sudden increase in the yield is as suspicious as a sudden fall, as it indicates that the supply is probably dependent on the rainfall. See what arrangements are made for ablution, and if the water is reasonably safe from contamination. See that the planning of the camp is carried out with due regard to the prevailing wind. It is essential to examine the proposed plan of the camp before giving a final verdict to fitness. Write to the Medical Officer of Health, and request some general details regarding local conditions; keep replies as a permanent record. I have had great help from the above source, and I have nearly always found it cheerfully and courteously rendered. Figs. 61 and 62 show the plans of actual camps comparatively recently occupied.

Duties on Board Ship.

The duties of a medical officer on board ship are a matter of regulation, but at the same time questions constantly arise

for which the authorities cannot legislate, and which have to be settled by personal judgment: The hospital should be on the main-deck, and as far aft as possible; for obvious reasons a hospital below is an abomination. There is naturally far more motion aft than there is amidships, but this drawback would be largely nullified if swinging cots were universally furnished. It is easier to keep men clean on shore than it is on board ship, and every patient should be most rigidly inspected as regards perfect cleanliness. On modern transports means of isolation and a disinfector are provided; the latter is placed in charge of the 'donkey-man,' and the manner in which this functionary discharges his duties is at times not altogether devoid of interest.

During a recent voyage I paid a visit to the installation in order to watch the working, and was then informed by the 'donkey-man'—who had obtained his information from a no less authority than the chief engineer—that steam was only required in the case of enteric fever, and that hot air answered all other requirements. The disinfector usually provided is the MacWhirter and Roberts type, and is very effectual when properly worked.

Itch is sometimes very difficult to eradicate on board ship; this partly arises from the fact that there is no proper tally on the bedding, and when a man is admitted to hospital the above is stowed away with the rest of such material, and there is no certain way of tracing that which has been used by any particular person. Means should be adopted for keeping apart the bedding of men admitted to hospital until the necessity, or otherwise, for disinfection has been decided. The bedding is stowed away by messes, and it is sometimes necessary to disinfect the bedding of a whole mess in order to insure disinfection of one particular set. In cases of itch the simplest way out of the difficulty is to have the bedding fetched at once, otherwise the opportunity to isolate it will be lost. Under present conditions the blankets of the sick are reissued to other men—a most unsavoury arrangement, and one which might well be abolished.

Drafts often come on board accompanied by nominal rolls

of men who have been inoculated once against enteric, the second inoculation being required a day or two after sailing. This is an essentially bad arrangement: the men should have both inoculations before embarking, on dates which will render it reasonably certain that they will come on board in sound health. At the beginning of the voyage already referred to, I received intimation that sixty-eight men would require the second inoculation two days after leaving Southampton. The weather was bad, and the men paraded in anything but a compliant frame of mind, most of them being seasick, and therefore not in a condition to appreciate the prospect held out by the medical officer who addressed them, and with one exception the second dose was firmly refused. As they left the troop hospital one man was heard to observe that there was misery enough on board already.

The food on transports is generally very good, but it is well to obtain the bill of fare from the chief steward, and see what the troops are actually receiving. A purchase of beer is allowed at the rate of one pint per man, and men can draw the authorized measure at 11 or 11.30 a.m.; it would be a far better arrangement to draw it at dinner-time.

It is not easy to keep troops on board ship in good health. There is not enough room on deck for all the men to sleep in the open, and the weaker and slower spend their nights in the fœtid air of the mess-decks. It is well to have an arrangement by which men can sleep on deck by rotation, so that all shall have a chance of enjoying the fresh air at night.

The mess-deck is both living-room and sleeping-room, and the space is restricted. An outbreak of infectious disease is always to be dreaded, and such an occurrence would be followed by startling consequences; no detail should therefore be despised which can contribute to maintain health and avoid disaster. Even during the day on a crowded deck, with an awning overhead, the ventilation may be most defective. A great deal has been said and written about the health-giving effects of a sea-voyage, but, as a matter of fact, a transport with the full complement of troops on board is, on occasion, a moving collection of mephitic gas.

CHAPTER XXVII

BUILDINGS AND TENTS

Barracks.

ALTHOUGH the general design of barracks is based on certain well-known principles, the arrangements in individual cases have to be determined by a host of considerations which do not permit of present discussion.

The demolition of old barracks and the construction of new must naturally be a matter of time, but the knowledge of certain principles may help to mitigate defects which cannot be actually remedied, being inherent in the structure of the buildings.

Barracks may be conveniently divided into three broad types:

1. The old type of large blocks, comprising many rooms beneath a single roof.
2. The casement barrack.
3. The separate block barrack.

The first-named type of barrack was essentially vicious in design, as, the rooms being placed in a general sense parallel with each other, and at right angles to the long axis of the building, and being divided by party walls, the construction of side-lights, with a corresponding increase of ventilation, was impossible. In some of these barracks the doorways are at one end of the rooms, and the windows at the opposite end; in others the door is placed laterally, so that a double row of windows exists. In some of the worst there is a central passage, with the rooms opening on either side, the arrange-

ment approximating to that of back-to-back houses. The married quarters in the South Raglan Barracks at Devonport and in the Verne Barracks at Portland are built on the last-named plan, and, when circumstances permit, they will doubtless come to an end, their defects being well known.

The ventilation in the old style of barracks, besides the windows and chimneys, consists of the metal valves already referred to, and which principally serve as a concession to appearances.

FIG. 63.—CORUNNA BARRACKS, ALDERSHOT: BLOCK TYPE OF BARRACKS.

Photo by Gale and Polden.

When barracks are designed as above, a whole host of other defects are usually found: the drainage is obsolete; the kitchens and regimental institutes are too small; the stores are badly situated and incommodious; and the whole place is often overrun with rats. In the old style of cavalry barracks the stables are under the rooms, and the latter are consequently infested with flies.

Another objection to placing the rooms over the stables is that it is difficult to keep the latter properly ventilated,

and, other things being equal, the worse the ventilation, the greater the number of flies. Dining-rooms, kitchens, grocery-bar, or meat-store may be found too near the stables, the food being therefore in danger of contamination by the above pests. In inspecting old barracks, a particular attention should be paid to the relative positions of buildings one to another. It will not be possible to reconstruct the barracks, but the defects may be mitigated by the re-appropriation of buildings. The latter came into existence

FIG. 64.—MALPLAQUET BARRACKS, ALDERSHOT: BUNGALOW TYPE.
Photo by Gale and Polden, Aldershot.

when hygiene, as we know it at present, was practically unknown, and when all kinds of insanitary abominations were viewed, not only with indifference, but with actual complacency, as forming a part of an established order which should not be lightly tampered with. The ignorance of bygone years has been perpetuated in the form of insanitary arrangements which are almost always found in combination, so that an old barrack is a perfect museum of defects.

2. *The Casemate Barrack.*—The casemate barrack must, in

the very nature of things, be unhealthy, as it is almost impossible to secure ventilation. Shafts are usually run from the vault of the arch, and the exits of these shafts demand attention. Many of our forts are of considerable age, and it is not surprising to find that their original designers seem to have been at special pains to defeat the object of the ventilating shafts by covering the upper openings of the latter by caps of stoneware, leaving the air to find its way

FIG. 65—CAVALRY BARRACKS, OLD TYPE: ROOMS ABOVE STABLES.

Photo by Gale and Polden, Aldershot.

out by grated openings placed parallel to the long axis of the shaft, and therefore at right angles to the air-current. A good deal of improvement may be effected by the substitution of some form of cowl for the arrangement which has just been described, or else by merely leaving the upper exit of the shaft open.

A common defect in old casemates is dampness; it is often caused by a worn-out, damp course, with consequent descent of moisture from the earthwork above. If the

number of weep-holes in the latter is deficient, the defect is naturally increased.

In casemates the men should be distributed as widely as possible; this proposal sometimes interferes with the internal economy of the unit, but the advantages usually preponderate over any inconvenience entailed.

3. The last type of barracks named is that constructed in blocks. Barracks of this type differ considerably among

FIG. 66.—EXTERIOR OF UNITED STATES ARMY BARRACK BUILDING FOR TWO COMPANIES.

Each half has a wing at the rear (not shown here) equal in area to one-third of the part shown, which contains mess-room, kitchen, pantries, etc.

themselves, but although they may not all be of the same standard of excellence, we have every reason to be satisfied with the general result.

When all new barracks have dining-halls, and when each room contains a smaller number of men, it will be rather difficult to suggest improvement. It has recently been decided to introduce cubicles, and the effect will be watched with interest.

A proposed scheme for French infantry barracks, shown in Figs. 69-73, may be of interest.

Dampness is occasionally complained of in new barracks. This is sometimes caused by defective workmanship, but it is more likely to result from the gradual 'setting' of the mortar. Mortar contains slaked lime, and when the latter combines with the carbonic acid present in the air of the buildings, carbonate of lime and water are both formed; the reaction is as follows:

$$\underset{\text{Slaked lime.}}{Ca(OH)_2} + \underset{\text{Carbonic acid.}}{CO_2} = \underset{\text{Carbonate of lime.}}{CaCO_3} + \underset{\text{Water.}}{H_2O}.$$

Another cause of dampness is the condensation of the vapour of the air on cold surfaces. Different kinds of plaster used by builders have different powers of heat-conduction, those of which powers are the greatest causing the most condensation.

Dampness for many reasons is a most serious defect. Our bodies, like matter in general, constantly radiate heat to surrounding substances. If the process went on unchecked, a uniform temperature would be arrived at throughout the world; but even then the action would continue, although the exchange would be an absolutely equal one, constituting a state of mobile equilibrium of temperature. As hotter bodies radiate more heat than those which are colder, it follows that in a room we radiate heat to a cold wall to a far greater extent than that radiated from the wall to us; and owing to the relatively large amount of heat required to raise the temperature of water, the wall, if damp, is likely to remain cold even if the air of the room has become disagreeably hot. Radiant heat does not warm the air, and we therefore continue to lose heat, which passes unchanged through the hot air to the cold wall; we are thus in the contradictory position of actually suffering from loss of heat in a hot room, and this will continue until the temperature of the wall reaches that of our bodies.

Barracks should never be occupied until the absence of dampness is actually insured.

There is one point which should always call for careful attention in inspecting barracks, and that is the establishment of properly constructed urinals for the various rooms. The old wooden urine tub is simply the fœtid relic of a barbaric past.

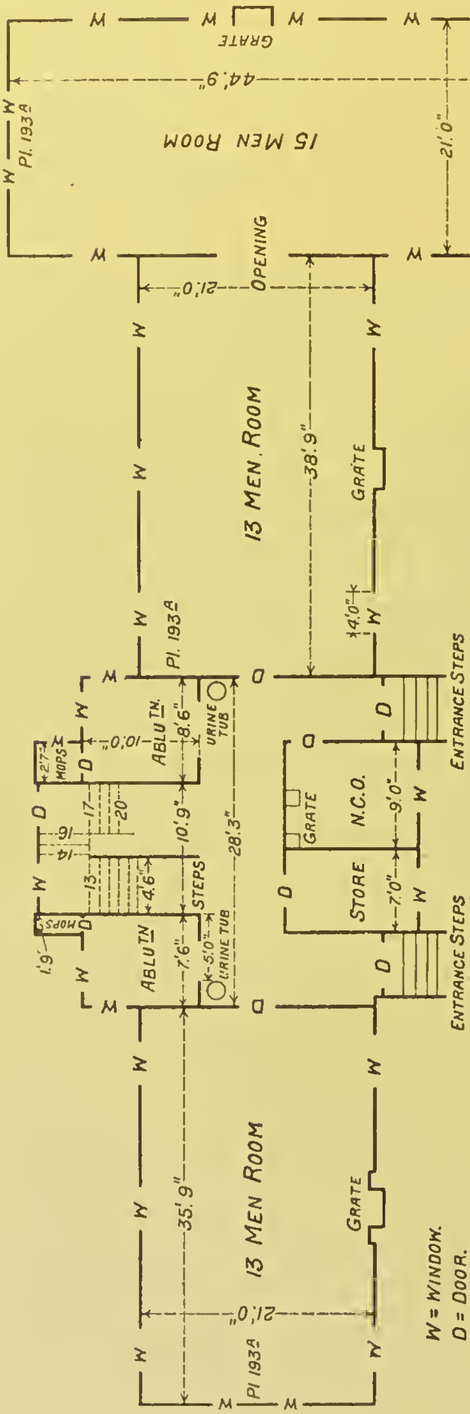

FIG. 67.—PLAN OF BRITISH BARRACK-ROOM: BLOCK TYPE OF BARRACKS.

In the future suitable means for drying clothes may be established in all barracks. In the Swiss army provision of this kind is considered necessary, and is therefore part of barrack accommodation.

BUILDINGS.

Medical officers are sometimes required to serve as members of boards for the purpose of examining and reporting on newly-erected buildings, previous to occupation as quarters. The following are the points to be particularly noted :

Exterior of Building.

Materials used in the construction of walls to be noted.

Hollow walls, in virtue of the low heat-conducting power of the air in the intervening space, are a protection against extremes of temperature. They are also a protection against damp. It is perfectly true that I never saw a hollow wall in any building used for military purposes, but this does not furnish a reason why the utility of the design should be unknown. In India the adoption of hollow walls with a

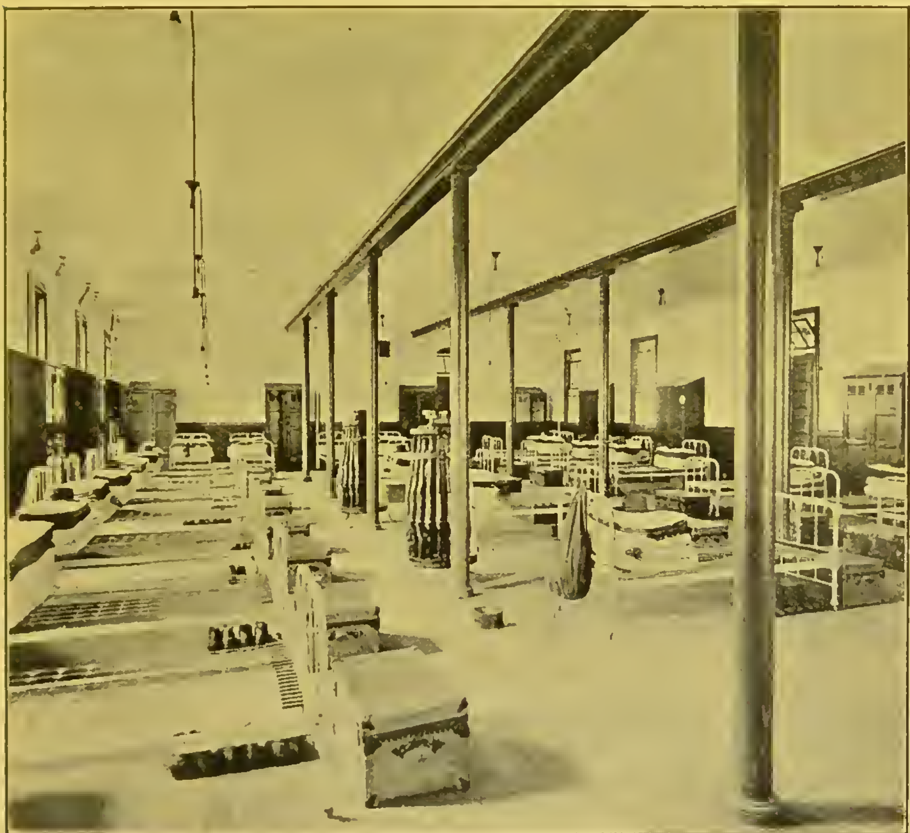

FIG. 68.—INTERIOR OF UNITED STATES ARMY BARRACK-ROOM.

ventilated air-space would be an enormous advantage, from the protection thus afforded against extreme heat ; but the arrangement might necessitate a more solid style of construction than that found in the average bungalow. Thorough ventilation of the air-space would be necessary, as otherwise the air, not being subject to constant renewal, would become heated, by conduction, to the temperature of its surroundings.

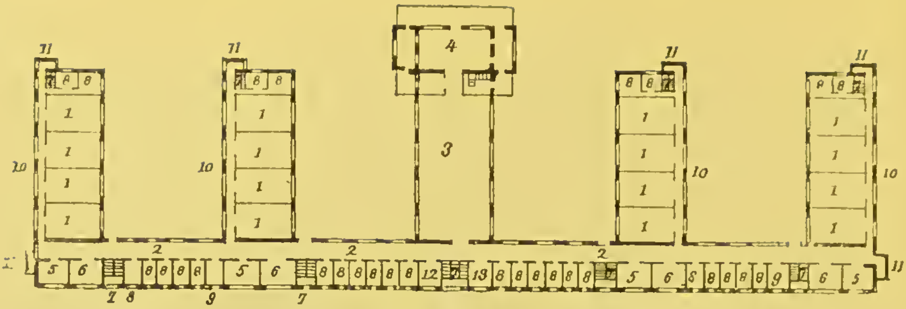

FIG. 69.—PROPOSED PLANS FOR FRENCH INFANTRY BARRACKS: GROUND FLOOR.

1. Dormitories.
2. Service passage.
3. Mess-room.
4. Mess-kitchen.
5. Lavatory.
6. Cloak-room.
7. Staircases.
8. Room of non-commissioned officers.
9. Orderly.
10. Service passages in dormitories.
11. Water-closets.
12. " "
13. Barber's room.

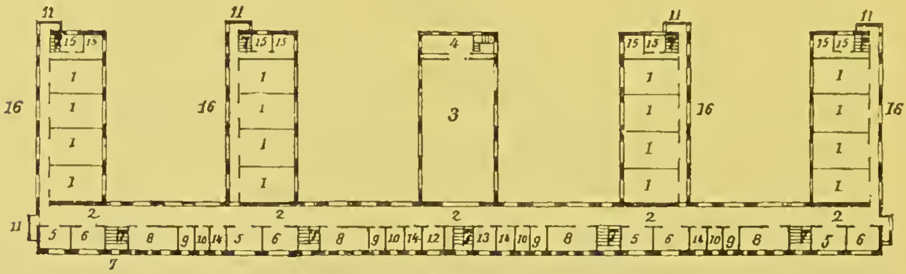

FIG. 70.—FIRST FLOOR.

1. Dormitories.
2. Service passage.
3. Canteen.
4. Canteen kitchen.
5. Lavatory.
6. Cloak-room.
7. Staircases.
8. Reading and writing rooms.
9. Company's offices.
10. Officers' offices.
11. Water-closets.
12. Colonel's office.
13. Library.
14. Store.
15. Non-commissioned officers' room.
16. Service passages in dormitories.

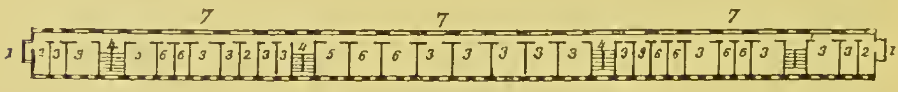

FIG. 71.—SECOND FLOOR.

1. Water-closets.
2. Lavatory.
3. Reservists' rooms.
4. Staircases.
5. Store.
6. Non-commissioned officers' room.
7. Service passage.

FIG. 72.—KITCHEN BASEMENT.

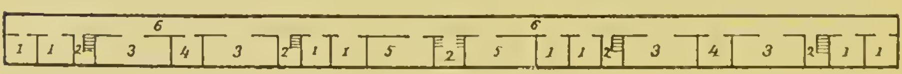

FIG. 73.—BASEMENT.

1. Cellars.
2. Staircases.
3. Steam drying-rooms.
4. Boiler-room.
5. Central heating-room.
6. Passage.

Brick walls are apt to be very permeable to damp, unless of first-rate quality, or covered with cement or other material of the kind. An ordinary brick is stated to hold 16 ounces of water.* The presence of a damp course should be ascertained. This is a horizontal layer of slate, glazed earthenware, or the like, running through the whole thickness of the wall and placed above the ground level, but below the level of the lowest timbers. It should be at least 6 inches above the ground. By this means damp is prevented from rising from the soil through the substance of the wall. The soil should never be banked against the house above the damp course, or the object of the latter will be defeated. If the ground is to be in contact with a wall, above the level of the lowest story, that wall must be made double, with a cavity 2½ inches wide extending from the base of the wall to 6 inches above the surface of the adjoining ground; and damp courses must be inserted both at the base of the wall and at the level of the top of the cavity (Model By-laws, L.G.B.).

Yards.—These should be paved with cement, concrete, asphalt, Staffordshire bricks, or Yorkshire flagstones. The bricks or flagstones should be laid on a bed of concrete. It must be remembered that both cement and concrete, in spite of the fact that they are widely used with good results for the purpose of checking the passage of moisture, are actually porous substances.

Drainage.—Notice ventilation of house-drain, and whether the ventilating shaft is carried above the eaves and is reasonably free from bends. Ascertain where the house-drain joins the sewer, and what means of ventilation, inspection, and disconnection are in existence. The usual plan of ventilation consists in a small mica valve contained in the expanded head of a pipe terminating at a variable distance above the ground, often about 2 feet, and communicating at its lower end with the drain. Air is admitted through a series of vertical openings in the expanded pipe-head. Both valve and apertures are generally too small to allow of the entry of a satisfactory current of air. This arrangement is often

* Parkes and Kenwood.

very badly placed. I recently saw one in the middle of a thickly-planted hedge. My attention was drawn to it by a military foreman of works, on the occasion of the sanitary inspection of a staff officer's quarters. An inspection-chamber at the point of disconnection between the house-drain and sewer is a most satisfactory arrangement; a detailed account of its construction and purpose can be found in any standard work on hygiene. It may briefly be described as a chamber, placed on the house side of the disconnecting trap between drain and sewer, in which the drains from the different parts of the house join together. The drains, after joining, terminate in a single trap which is the means of disconnection between the sewer and the house. The walls of the chamber are generally constructed of brickwork rendered in cement, and the whole is designed with the object of being absolutely water-tight. The chamber is closed with an iron cover; the latter may be grated if the chamber is at a suitable distance from the house, otherwise the cover must be air-tight, ventilation being effected by the arrangement previously named. By means of a disconnecting chamber the drains can be inspected and the efficacy of the disconnecting trap insured.

Refuse Disposal.—Examine ashpits and note materials used in construction, and ascertain whether damp-proof or otherwise. According to the Model By-laws of the Local Government Board, 'the capacity of an ashpit must not exceed 6 cubic feet, or such less capacity as may suffice for a period not exceeding one week. The walls must be of flag, slate, or brick, at least 9 inches thick, and rendered inside with cement; the floors must be flagged or asphalted, and raised at least 3 inches above the ground level. The ashpit must be roofed and ventilated, and provided with a door so arranged as to allow of convenient removal of the contents, and to allow also of being closed and fastened. The ashpit must not be connected with any drain.'

Rain-water Pipes, Kitchen Pipes, etc.—Note the points of discharge from rain-water pipes, pipes from kitchen sinks, and pipes from bathroom; ascertain whether the two latter

are trapped. All these should discharge into a surface-drain, and in the proximity of a trapped gully ; or they may discharge directly over the latter. They should not discharge beneath the grating, as a trap, in this case, may not always prevent the entrance of foul air into a dwelling. According to the Model By-laws of the Local Government Board, the distance from the point of discharge to the gully should be at least 18 inches. As a matter of fact, it is very common in the service to find waste-pipes which discharge beneath the grating of the gully ; the reason assigned is the prevention of splashing, an object which could perfectly well be attained by means of a suitable ' curb,' the latter consisting of a rim a few inches high round the gully grating.

Ground Ventilation.—Ascertain the means of ventilation beneath floors. There should be at least 3 inches between a boarded floor and the ground on which the building stands. The ground beneath the building should be covered with concrete, asphalt, or other similar material. In default of these precautions, the heated air in the interior of the house, having an aspirating effect on the ground air, may cause the latter to be drawn into the rooms ; it is quite conceivable that microbial forms of life may effect an entrance into dwellings by these means.

Interior of Buildings.

Water-closets. — Notice position of water-closets. They should be placed next to the external walls of the house. In some married quarters they are placed at the ends of the verandas. This, for some reasons, is a good position ; on the other hand, it causes the accommodation to be limited. The closet should be ventilated into the external air. I remember a closet, in Edinburgh, which was ventilated directly into the kitchen. Notice the pattern of water-closet ; siphon closets of the ' wash-down ' type are the best. If the closet is supplied from a cistern, ascertain whether the cistern supplies any other part of the house. A cistern which supplies a water-closet should not contain water for any other purpose.

Water-supply.—Inquire whether the water-supply is on the constant or the intermittent system, and if the latter, examine carefully the position of the drinking-water cistern, and see that it is sufficiently protected. The intermittent system is still in existence at some stations, but should be abolished where possible.

Kitchen.—Examine range, and means for boiling water,

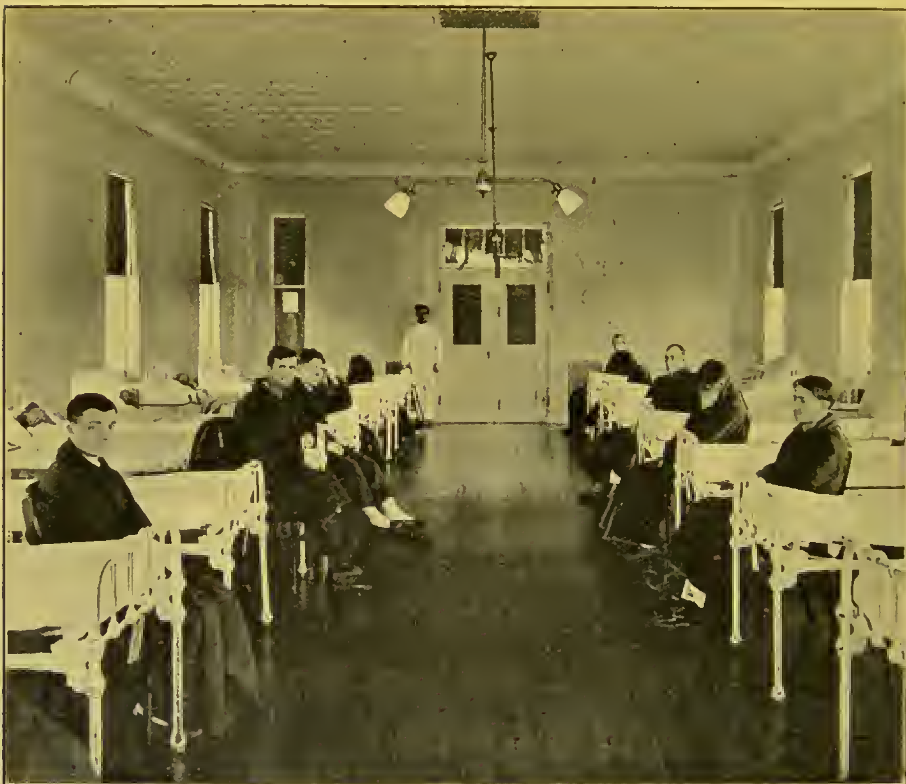

FIG 74.—INTERIOR OF UNITED STATES ARMY HOSPITAL: WARD FOR EIGHTEEN PATIENTS.

Note also position of scullery and pantry, particularly in reference to that of the water-closet.

Rooms.—Count number of rooms, and ascertain the purpose for which each is intended. See that each room is provided with a fireplace, and note the means of ventilation. The usual mechanical contrivances are rarely satisfactory in the

absence of properly-constructed windows. As already pointed out, Professor Glaister's design for window ventilation would be admirably adapted for quarters. Ascertain whether the woodwork of the sashes and frames of windows is properly seasoned, and that the movement is sufficiently free. I recently saw a row of married quarters, which had only been in occupation a few days, in which the windows were

FIG. 75.—WARD IN CONNAUGHT HOSPITAL.

Photograph by Sergeant-Major A. Harwood, R.A.M.C.

hermetically sealed, owing to the expansion of the unseasoned wood in the window-frames, after a heavy rain-storm. The interiors, occupied by a mixed population of men, women, and children, were, to say the least of it, unpleasant.

Roofs.—Note materials used in construction of roof, and also whether there is a ceiling in the upper rooms. There should always be an air-space between the ceiling of the highest room and the roof. Tile roofs are very common in

Bengal and the Punjab; when unprovided with a ceiling they are sanitary abominations. The tiles are good conductors of heat, and in the hot weather they are a source of very serious danger. A room may also be rendered absolutely uninhabitable by the heat radiating from a metal roof, in the absence of a properly-constructed ceiling and air-space. In some parts of South Africa corrugated-iron roofs without a ceiling and air-space are common. The resulting heat and discomfort are indescribable. Roofs of the above kind—either tile or metal—are as objectionable on the score of cold, in the winter, as they are on that of heat, during the summer.

Lighting.—If gas is laid on, note the rooms in which burners are placed. An extra burner may be a great convenience to future inmates, and would generally be installed on the recommendation of a board. Notice the type of burner; for reasons stated the Welsbach burner has much to recommend it.

Hospitals.

Most of the points to be noted in regard to barracks and buildings generally apply equally to hospitals. The general arrangements of hospital wards, lighting from windows, bath and lavatory accommodation, and position of beds, are matters of common experience.

The cubic and floor space allowed for patients is decided by regulation, so that there are only a few points that need be mentioned here. In some of our military hospitals the latrines are too near the wards; a cross ventilated passage should always intervene. Plank floors are undesirable. They are very difficult to keep clean, as dirt accumulates in the crevices. A parquetted floor is far preferable, but would be decidedly costly. The floors of wards, in some hospitals, are constructed of teak; this was the case at St. Helena, and, I believe, it is the case at Woolwich; if well rubbed with 'Ronuk,' these floors are very easy to keep clean, and the teak is, of course, most durable. The patent 'Duresco'

is very useful for colouring walls; it has the advantage of being washable.

Ventilation is usually obtained by one or other of the devices already mentioned. Warming of hospitals can be conveniently effected by means of steam under low pressure. Hot water has no available latent heat, and it is difficult to regulate the flow.

In foreign stations the general arrangement and structure of barracks and hospitals have to conform to local requirements, and a detailed discussion of the matters involved in this connection would be impossible. In some cases, as at Cairo, existing buildings are utilized for both the above purposes.

One-story structures, with wide doorways and verandas, constitute, in general terms, the form of either barrack or hospital best adapted to the tropics and hot countries generally. Local conditions having been considered, common-sense principles of sanitation will lead to a decision as to the suitability of any building for the purpose intended by its designer.

Tents and Huts.

Tents.

One of the very best tents for service is the European Private's Tent (Indian Pattern). The sides can be removed, and effectual ventilation thus secured. These tents were favourably reported on in South Africa. The supporting ropes are made of cotton, and practically unshrinkable when wet; this is a great advantage. The disadvantages of the tent are found in its weight, which is about 600 pounds, and also in the fact there is no ridge or roof ventilation. Another excellent tent is the tortoise tent. It has been well spoken of in a paper read before the meeting of the British Medical Association in 1904 at Oxford. Surgeon-Lieutenant-Colonel C. R. Kilkelly, C.M.G., the author of the paper, at the same time drew attention to the cumbersome nature of the hospital marquee. The last-named tent is certainly

comfortable, but the labour of erection is a serious drawback to its use; its weight is 512 pounds.

The very worst tents imaginable are the bell-tents, which up to the present have been the usual means of shelter adopted for field hospitals. It is satisfactory to know that they received condemnation in an excellent paper read by Brigade-Surgeon Lieutenant-Colonel Giles at the meeting just named; the views of this officer, from his long experience and well-known association with the volunteer movement, should carry particular weight; my own experience leads me to fully endorse the opinions expressed by him. The tents are badly ventilated at any time, and when the flies are let

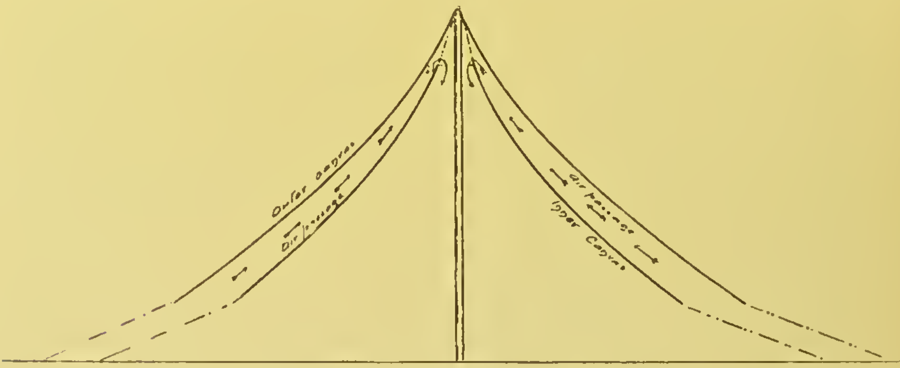

FIG. 76.—DIAGRAM SHOWING AUTHOR'S SUGGESTED MEANS OF VENTILATION IN DOUBLE FLY BELL-TENT.

Drawn by Quartermaster-Sergeant Revill, R.E.

down and the doors laced up they are not ventilated at all. A suggested means of ventilating these tents is shown in Fig. 76. The largest has an internal capacity of 672 cubic feet, and the tent is supposed to accommodate fifteen soldiers or four patients. They have probably remained in favour for the reason that they are readily pitched and weigh approximately 45 pounds each.

The service-tent, in use in India, is a vast improvement on the bell-tent. The general appearance of field-hospital service-tents is shown in Figs. 77 and 78. In South Africa the contrast between the service and the bell tents could scarcely fail to impress all whose duties brought them into

FIG. 77.—SERVICE-TENT FOR USE OF MEN IN INDIAN FIELD HOSPITALS.

contact with the sick and wounded in the field. The Indian field hospitals alone were provided with the former kind (Fig. 77). Whatever design of tent is adopted, a great point to be remembered is that the outer flies should be so fixed as to provide a free current of air between them and the body of the tent. The Indian tent for patients is

FIG 78.—SERVICE-TENT FOR PATIENTS IN INDIAN FIELD HOSPITALS.

Photograph by Captain Byrnes, I.S.M.D.

certainly susceptible of improvement in this respect (see figure). Although possessed of comparatively low powers of heat-conduction, air, when stagnant, is capable of allowing the passage of heat to an extent which, in the present case, tends to nullify the object with which the external flies are designed. For this reason a bell-tent furnished with external flies closed at the top does not differ to any really marked degree, in its protective powers against heat, from a tent provided with only a single thickness of canvas.

No general account of tents would be complete without reference to the admirable design of Major Munson, United States Army. The following is Major Munson's official description of his improvements in tentage:

'With the military occupancy of our new island acquisitions the unsuitability for tropical climates of our regulation tentage, particularly that used for the shelter of the sick, became at once apparent. While not seriously defective when used under the conditions of weather and temperature for which they were originally designed, the several types of tent used in our service are all intensely hot and close under

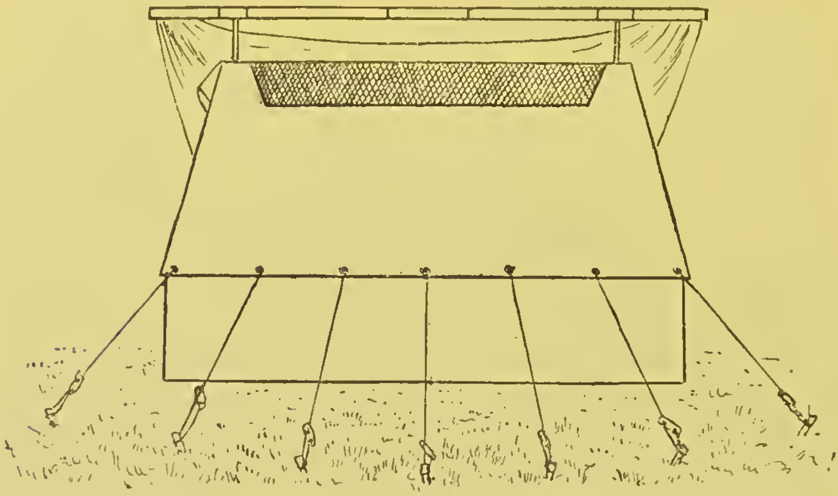

FIG. 79.—MUNSON TENT.

the vertical sun and in the humid atmosphere of the tropics. With reference to the hospital tent, these undesirable qualities appeared to be presumably due—

'1. To the impingement of the direct solar rays upon the single thickness of canvas of the walls and sides.

'2. To the insufficient air-space and limited opportunity for the movement of air between the fly and roof of the tent.

'3. To the inadequate size and improper location of the openings for ventilation.

'After some consideration the writer suggested the follow-

ing changes in the regulation hospital tent, which it was believed would materially improve the latter for service in the Torrid Zone:

'First. That the present tent-fly be enlarged 2 feet in length and 4 feet in width.

'Second. That this fly be raised upon a light false ridge placed 1 foot above the true ridge, this false ridge being 4 feet longer than the true ridge, and projecting 2 feet to the front and rear. This is accomplished by lengthening the present pole-pins by 1 foot, and providing two suitable metal-lined sockets in the false ridge for their reception. This false ridge is provided with a short pin on the upper aspect of each extremity to keep the canvas in position, while, to facilitate transportation, this false ridge is divided obliquely in the centre and enclosed in a galvanized-iron box to form the joint.

'Third. That the canvas comprising the top of the tent be cut out for a space 2 feet wide on each side of the ridge and running the entire length of the tent, except 1 foot front and rear. The canvas thus removed is replaced by heavy rope-netting having a mesh about 2 inches square.

'Fourth. That the tent-fly be white in colour, to better reflect the heat rays, while the tent itself is drab, to render the light in the interior properly subdued.

'Through the kindness of the Surgeon-General, a tent made on the above plan was sent to Washington Barracks for trial, as a result of which trial, extending over a number of weeks, I feel justified in making the following claims for this tent:

'First. That with walls down this tent in a summer or tropical temperature will be from 7° to 10° cooler than the regulation hospital tent, and from 10° to 18° cooler than the new model conical wall-tent. This fact was determined by pitching these three tents closely together and observing the inside temperatures, as also that under the dense shade of a neighbouring tree. The following readings were obtained by consecutive observations:

	Improved Hospital Tent.	Present-style Hospital Tent.	New Model Conical Wall-tent.	Dense Shade.
First reading	84·0	89·0	93·5	79·5
Second reading ...	86·0	94·5	94·0	80·5
Third reading	86·0	93·0	97·0	83·0
Fourth reading ...	89·5	99·0	107·0	84·0
Fifth reading	93·0	97·5	106·5	86·0

'These five readings show an average temperature of 94·5° for the regulation hospital tent, and 87·5° for the improved hospital tent, an average difference of 7°. On one occasion, subsequent to the above, a difference of 10·5° was noted. As compared with the conical wall-tent the difference was even more marked, ranging from a minimum of 9·5° to a maximum of 18·5° in favour of the improved tent.

'Second. That with walls rolled up this tent averages with summer temperature 4° or 5° cooler than the old-style hospital or conical wall-tent, closely approaching the temperature of dense shade from foliage.

'Third. That this tent, owing to its free ventilation (as at present planned, it has 48 square feet of ventilating space, where the old-style tent has about two-thirds of 1 foot), is nearly as cool with walls down as with walls up, an average difference of only 3° or 4° being noted. This property is of particular value for hospital tentage, where the seclusion of the sick and their immunity from intense light and disturbing outside influences will do much toward promoting recovery.

'Fourth. That in case of necessity more than the six patients ordinarily allotted to each hospital tent may be safely placed in this tent, since the ventilation is so free that the inmates are practically in the open air.

'Fifth. That when several of these improved tents are pitched together to form a hospital ward a continuous roof is formed by the large flies, while the tents are themselves located 4 feet apart, thus dividing the ward into tent sections, permitting free lateral ventilation, allowing

FIG. 80.—FIELD HOSPITAL, UNITED STATES ARMY: MUNSON TENTS ARE SEEN TOWARDS THE BACKGROUND.

Photograph by Sergeant First-Class Julius Leithinger, United States Army Hospital Corps.

entrance or egress of the inmates of each tent without the necessity of passing through the other tents of the ward, permitting the ready isolation of each tent section in the case of contagious disease, and, finally, in furnishing a covered inter-space which may be excellently utilized for the shelter of ward property or the recreation of convalescents.

'Sixth. That the total weight of this tent is increased, as compared with the old tent, only by the slight additional weight of the light false ridge and the extra canvas of the fly.

'Seventh. That the portability of the new tent is the same as the old-style tent, since the long false ridge is made in two parts to facilitate transportation.

'Eighth. That no great or costly changes in the existing hospital tentage are necessary, and that the tentage now in use may be readily remodelled on the improved plan suggested.

'Ninth. That in case of loss or injury to the false ridge or large fly the present-style fly may be used and will give perfect protection to the interior when placed on either the true or false ridge.

'Tenth. That in case this tent is at any time required for use during cold weather, it may readily be made as snug as the old tent by merely placing an ordinary fly over the true ridge under the false ridge and large fly, and pegging it down, so that the smaller fly will lie against the tent roof, and thus close the large ventilating opening.

'Eleventh. That this tent is as stable as the ordinary hospital tent. This fact has been amply demonstrated by the high winds which have on several occasions prevailed during the period in which this tent was undergoing trial. This tent is preferably pitched with a double set of guy-pins, and hence is more firmly held to the ground than the old-style tent.

'Twelfth. That by the use of the overhanging fly and the corner fly guy-ropes, stretched at the proper angle, the necessity for the use of the long and inconvenient end-

stays required to steady the old-style tent is done away with.

'The above claims are borne out by the reports submitted by the special inspectors of the medical and Inspector-General's departments detailed to investigate and report as to the advantages and practical utility of this tent, as a result of which reports this tent has been adopted by the board of equipment for use in the military service.'*

The above report is worth careful study, as it illustrates the advantages of a principle—viz., free ventilation beneath flies—which should be adopted in all forms of tentage.

An excellent modification of the 'Munson' tent is the 'Hubert' tent. This tent was in use in the 10th Canadian Field Hospital in South Africa. A Board of Medical Officers report on it as follows:

'The Board have formed a very high opinion of this tent, and consider it very suitable for both mobile work in the field, and for stationary work. It is far superior to any pattern tent which they have seen in South Africa, and would strongly advise its introduction in our field equipment.†

* * * * *

'It is oblong, has low walls, an angular roof with ridge, and beneath this roof the tent proper, separated from the roof by an interval capable of variation, but usually 1 foot.

'The tent proper is nearly square in shape, the length being 16 feet, the breadth 15 feet. The height of the side-walls is $3\frac{1}{2}$ feet, and the entire height to the inner roof 11 feet. The cubic accommodation works out at 1740 cubic feet.

'The tent proper is made of duck, which is heavier than that of the outer fly. It is made up of six lengths. The centre four of these are shorter at the upper end, thus

* Report of the Surgeon-General of the United States Army for the Fiscal Year ending June, 1899, pp. 230-232.

† Report of Surgeon-General Sir W. D. Wilson, K.C.M.G., on the Medical Arrangements in the South African War, p. 88.

leaving a space which is filled in with netting for purposes of ventilation.

*   *   *   *   *

'The tent is capable of holding on stretchers ten patients comfortably, and twelve with the stretchers nearly touching. In cases of great emergency, twenty patients can be accommodated on blankets on the ground. If fitted with beds of the Lawson-Tait pattern, seven patients could be comfortably accommodated.'*

The weight of the tent is 150 pounds, and it takes four men to pitch it.

Guy-ropes of unshrinkable cotton are quite worthy of an extended trial. The shrinkage of the ordinary ropes is a matter of common experience; not only is it a source of worry and discomfort, but is a very serious danger in the case of sick or wounded men. If the loosening of the ropes is omitted on a rainy night, there is a very good chance of the tent being down before the morning.

Huts.

Corrugated-iron huts are easily erected on service, and special knowledge is not required for the purpose, but certain points are essential in their construction. They should be lined either with wood or felting. Genuine match-boarding is not likely to be obtainable in the field. Felting, for many reasons, is not desirable when wood can be obtained. The smell of the former is disagreeable, and it is difficult to keep clean. Felting placed between the wood and the iron, from its low conducting powers, protects well against either heat or cold, and the disadvantages just referred to are materially lessened. If felting is not used a ventilated air-space should be left between the wood and the iron. If the two latter are in immediate contact, the conducting power of the iron renders the interior of the hut either oppressively warm in summer or bitterly cold in winter. We had huts, of corrugated iron and wood, constructed on

* Report of Surgeon-General Sir W. D. Wilson, K.C.M.G., on the Medical Arrangements in the South African War, pp. 331 and 333.

the above lines at Olivier's Hoek in the Drakensberg, during the winter and spring of 1902. They were a vast improvement on the tents, and the verandas, which were in some cases provided, constituted an additional comfort. Some form of wooden flooring in either huts or tents is most desirable. Earth, even if rammed hard, gets horribly foul in a short time. There should be the freest ventilation possible between wooden floorings and the ground; the latter, beneath huts, should be covered with concrete or the like. Old pieces of canvas do not make a bad floor, as they can be taken out daily and sluiced in water and exposed to the air, and, in warm weather, dried in the sun. It may here be incidentally observed that the bactericidal powers of sunlight are not utilized on service as fully as they might be. It is an excellent plan not only to strike tents for as many hours of the day as possible, but also to expose articles of clothing, etc., whenever possible to the full glare of the sunlight. It is not necessary to strike the Indian service-tent (Fig. 77), as the canvas on each side can be thrown over the ridge-pole. The canvas can be raised on either side alternately according to the direction of the rays of the sun.

CHAPTER XXVIII

PHYSICAL DEGENERATION IN ITS CONNECTION WITH THE ARMY

It is a matter of general knowledge and widespread interest that certain allegations, derived from a variety of more or less authoritative sources, have given ground for a belief that a progressive physical deterioration is taking place among those classes of the population from which the ranks of the army are for the most part recruited. An Inter-Departmental Committee, appointed by the Duke of Devonshire as Lord President of the Privy Council, on September 2, 1903, to make a preliminary inquiry into the subject as a whole, was unable to discover accurate evidence of 'any general progressive physical deterioration' such as had been stated to exist. This conclusion is, of course, eminently satisfactory, but at the same time the list of recommendations framed by the committee in the interests of public health show the direction or directions in which factors detrimental to the well-being of the poorer classes of the community unquestionably lie. It may therefore be useful to endeavour to sketch briefly the extent to which these factors are eliminated or modified in military service, and to obtain at the same time, by these means, an idea of the effect which the army produces on the physique of the nation at large.

The following are matters which are dealt with in certain of the principal recommendations of the committee:

1. Overcrowding.
2. Buildings and open spaces.
3. Smoke pollution.
4. Register of owners of houses.
5. Law as to insanitary and overcrowded house property.
6. Medical inspection of factories.
7. Workshops.
8. Alcoholism.
9. Food and cookery.
10. Cooking grates.
11. Adulteration.
12. Milk-supply.
13. Feeding of infants.
14. Milk depots.

The preceding are only a few headings out of a long list, and although it would lead too far from present purposes to attempt a seriatim discussion of the above, it is plain that attention is principally directed to the question of food and air, while the influence of drink on health is not omitted. The committee are also of opinion that the habits of the people themselves are largely accountable for conditions directly detrimental to health.

Sir L. H. Ormsby, in giving evidence, stated as follows: 'In the lower strata of society in large towns I consider their surroundings and domestic life are in a very depressing condition; there is a total neglect of every hygienic and sanitary rule of life, and these conditions, I say, are perhaps made up of the insanitary dwellings, the insufficient and improper food and insufficient clothing, and breathing and re-breathing the same polluted and contaminated air; and then they have no means of recreation and athletic games to throw off these effects.'*

In the September issue for 1904 of *Public Health* there is a highly interesting résumé of the work of this committee, in which the following statement occurs: 'Laziness, want

* Report of Inter-Departmental Committee.

of thrift, ignorance of household management, and particularly of the choice and preparation of foods, filth, indifference to parental obligations, drunkenness, largely infect adults of both sexes, and pass with terrible severity upon their children.'

The above general statements may be conveniently summarized, for purposes of comparison, by setting forth the main causes of physical deterioration as—

1. Insufficient pure air.
2. Improper food.
3. Alcohol.
4. Dirt in domestic life, to which may be added improper or insufficient clothing.

1. The results of impure air are sufficiently well known, and their relation to overcrowding needs no prolonged comment. 'In seven groups of districts with an increasing amount of population living in overcrowded tenements, the infant death-rate has followed the increase from 142 per 1,000 to 223 per 1,000'* (Murphy).

Contrast these figures with the mortality of soldiers' children in the United Kingdom; also in India, where conditions are particularly inimical to the earlier years of life.

MORTALITY-RATE OF CHILDREN PER 1,000 IN THE UNITED KINGDOM AND IN INDIA FROM 1895 TO 1903 INCLUSIVE. †

United Kingdom.		*India.*	
1895	21·29	1895	41·24
1896	16·57	1896	45·60
1897	20·36	1897	50·49
1898	18·25	1898	41·13
1899	18·31	1899	41·03
1900	20 82	1900	46·88
1901	16·62	1901	32·95
1902	14·39	1902	45·23
1903	12·97	1903	36·99

* H. E. Armstrong, M.O.H., Newcastle-on-Tyne, 'Overcrowding in Houses,' *Public Health*, February, 1905.

† Army Medical Reports for above years.

An objection may be raised to the above figures on the ground that they include children at ages which are not to be comprised in the term 'infancy.' This is no doubt in a measure perfectly true, but it must not be forgotten that men cannot marry 'on the strength' during the early part of their service; that practically all the children included in these figures were born in the army of parents shown on the 'married strength'; and that transfer to the reserve takes place early in life. If these facts are kept in mind, it is plain that the number of infants, in soldier's families, must be relatively high.*

Major R. J. Blackham, R.A.M.C., has shown that for the decennium 1897 to 1906 the average infant mortality among the married families of H.M. troops at Devonport was 43·09 per 1,000 births as contrasted with 134·6 per 1,000 in the civil population of the same town. Dr. Routley, M.O.H., Aldershot, has set forth some highly interesting figures pointing in the same direction as the above; these figures are as follows: during the quinquennium, 1902-1906, there were 62 deaths from diarrhœal diseases among infants in the town of Aldershot, and 17 from the same cause in the camp. The births in the two districts during this period were in the proportion of 4 to 3, viz.: 2,800 in the town and 2,092 in the camp.†

* Contrast the above table with the following figures from the Report of the M.O.H., Sheffield, for 1904:

MORTALITY AT CERTAIN AGE-PERIODS.

Ages.	Death-rate per 1,000 Persons living at each age of Group.						
	1898.	1899.	1900.	1901.	1902.	1903.	1904.
Under 1 year ...	225·2	229·3	228·3	236·5	175·8	212·3	178·9
1 and under 2 years...	74·7	79·7	85·1	70·4	46·0	76·0	46·5
2 ,, 3 ,, ...	28 0	34·3	36·0	27·3	19·6	26·0	17 0
3 ,, 4 ,, ...	15·3	25·2	22·9	16·0	11·1	17·6	12·2
4 ,, 5 ,, ...	10·5	17·4	14·6	12·7	7·7	7·8	8·2
Total under 5 ,, ...	77·2	83·6	83·7	79·3	56·6	73·5	57·2

† 'Infant Mortality and Parliamentary Legislation,' *Journal of the Royal Sanitary Institute*, vol. xxix., No. 8, 1908.

It may be stated that the respective rates of child mortality in civil and military life have no direct relationship with the present issue. This objection is, however, not a fair one, for it must surely be admitted that a high rate of infant mortality, other things being equal, is an indication of the physical condition of children generally, and this being so, there can be no question as to the available evidence being overwhelmingly in favour of the soldier's offspring. Additional evidence, if such is required, can be obtained by contrasting the married quarters in any modern barracks with the general average of artisans' dwellings. That the health of the race is dependent on the health of the infant population is a proposition which does not need discussion.

The manifest advantages which the soldier enjoys in this particular direction—*i.e.*, pure air—as contrasted with the civilian operative, have already been touched on in a former chapter. It may now be added that the former is absolutely removed from the risks attendant on an atmosphere containing any of those industrial poisons which go to swell the death and sick rate of the working population.

2. The food of the working classes, no doubt, varies enormously, but that there exists great need for improvement in many respects, notably in the case of milk, is a matter of sufficiently common knowledge to all who pay even a moderate amount of attention to current medical literature. In the first place, the average artisan has little or no security against dishonest retail trade. So evident is the importance of this fact that the committee already named recommended that the Local Government Board should be authorized to fix a standard of purity for all food, in the same way as standards of butter and milk have been fixed by the Board of Agriculture. Against fraud of the above nature or against the consumption of unsound meat, the soldier, if not entirely, is nevertheless almost entirely, protected. All bread and meat are submitted to an intelligent and a common-sense examination by men whose good faith is beyond question. Although some additional safeguards have been suggested in the chapter on Food, I cannot, in twenty-

five years, recall a single case in which men or officers suffered anything which could be reasonably called detriment from fresh rations issued either at home or abroad. Disaster has been known to follow the use of tinned rations in the field, but accidents of this kind are unavoidable, and although with great care they may be reduced to a minimum, they must be accepted as one of the risks of war.

In peace the supplies sold in the canteen and grocery bar are under the constant supervision of regimental and medical officers. Frequent inspections insure absolute cleanliness; and the men are fully aware that reasonable complaints are not disregarded. Considering the 'keenness' which regimental officers show in maintaining the efficiency of regimental institutes, it is scarcely conceivable that the soldier can be subjected to the frauds and dangers which are commonly believed to attend the purchase of articles of consumption from certain of the retail dealers who depend for their living upon the custom of the poor. It would be absurd to assert that fraud is never attempted in the army. Elsewhere I have cited an instance of the kind in the case of a milk-supply; but it may be asserted that acts of this nature can only be carried out in the face of difficulties which are absolutely unknown to the retailer whose customers are found only in civil life.

With regard to cooking and the care of food, the contrast between the lot of the civilian and the soldier is one of the most striking instances of the hygienic influences which the latter enjoys. In the service, properly-appointed stores exist for the care of bread and meat. The stores are locked, and in trustworthy charge. They are constantly inspected, and neglect in their care would be followed by unpleasant consequences to the culprit. The cook-houses likewise are scrupulously clean, and the non-commissioned officer in charge is responsible that they are kept so, and that due care is exercised in the process of cooking. Food is constantly varied, and consumed, under conditions of cleanliness and order. It is part of the duty of the orderly officer to ascertain the absence, or otherwise, of complaints at the

dinner-hour, so that the men have every chance of bringing reasonable defects in the food, or in the mode of cooking, to official notice. The non-commissioned officers are responsible for the necessary cleaning up after dinner, and that the débris are duly disposed of.

Compare this brief outline of one item in the soldier's life with what, in a similar connection, commonly falls to the lot of the poorer class of working man: the semi-putrid offal sold by cheap butchers in a populous district; the cooking carried out in the fœtid atmosphere of an apartment which often serves the general purpose of dining-room, bedroom, smoking-room, nursery, and maternity ward; the unsavoury fragments of the repast set aside for future use, and exposed in the meantime to the influence of products of the human frame, the very association of which with food excites nausea and loathing; and the whole squalid transaction, from the time of purchase to that of consumption, unredeemed by any feature of comfort, cleanliness, or physical cheer.

Among other delicacies comprised in the menus of the London poor, 'jacko' occupies a prominent place—this is horse-flesh; it is sold as cat's-meat, but consumed largely by human beings. A recent report in this connection of the Medical Officer of the London County Council furnishes details which serve to render still more striking the contrast now in question.

3. *Alcohol.*—The subject of alcohol in the army has already been discussed at some length, and it has been suggested that the habits of the soldier, and of the married families in quarters, may contrast not unfavourably with the corresponding class in civil life. The ground for this suggestion is to be found in certain of the circumstances under which persons residing in barracks are placed, and to the fact that acts of intemperance are punishable according to the terms of the Army Act; the punishment varying in severity according to the frequency of the offence, and the conditions under which it is committed. Even allowing a certain latitude in the way of absence of vigilance, it is utterly impossible for a soldier to drink to that wholesale extent which is one of the

privileges of the ordinary citizen. The raving drunken brute who terrorizes his neighbours and maltreats and starves those who are dependent on him for food could not exist in the army, for the very good reason that discipline would very soon be productive of an altered frame of mind with a corresponding improvement in general demeanour. Another important point is found in the fact that the soldier cannot starve himself to procure drink. No matter what his habits may be, his ration is daily made ready for his consumption.

Spirit-drinking in the army is, I believe, uncommon, and as great care is taken to insure the excellence of the beer sold in the canteens, the men are, while in barracks, protected from the 'doctored' liquids of the retail house.

As stated already, drunkenness among the married families appears to be altogether exceptional. Here, again, the good effects of official control become manifest. I do not think it unfair to add that enforced control in regard to the drinking habit may induce voluntary control, and this assumption is strengthened by the fact that a varied and fairly extensive experience leads me to entertain a strong conviction that the confirmed alcoholic in any of the ranks of the service, or among soldiers' families, is exceedingly rare.

4. *Dirt in Domestic Life.*—This, being a general term, admits, in consequence, of loose application, but if it is limited to the surroundings and habits of the lower class its meaning becomes sufficiently defined for most purposes. Accurate statements will scarcely be required by those who recollect the appalling dens where students attend a prescribed number of cases of midwifery, in London, and other large cities. The loathsome filth and squalid misery of these dreadful habitations are a sufficiently striking contrast to even the very poorest married quarters of any regimental lines. Residence in these quarters is conditional on proper conduct, and the very presence of neighbours produces, among the occupants, a healthy and mutual self-repression as regards undesirable habits, and a correspondingly healthy and mutual emulation in the direction of self-respect and

decency of living. That the general results of this frame of mind are excellent can be amply proved to any unprejudiced person who will take the trouble to visit married lines and contrast the cleanly and well-to-do appearance of the families with the general run of artisan-dwellers in our cities.

Clothing.—From a hygienic point, it would be difficult to point out any radical defect in the soldier's garments. The silver-grey flannel shirt is of excellent quality; woollen drawers are provided for infantry, and similar garments in cotton for mounted corps. The uniforms—with the exception of khaki drill, which is cotton and in so far undesirable—are of somewhat uncertain composition, but I never heard of any evil results being traced to their use. The underclothing is duly washed, and other garments are required to be kept clean.

The civilian labourer buys his own clothes, and, not being protected by the State, is commonly defrauded. Frauds are frequently practised by disguising cotton as woollen goods. The value of wool has already been explained, and the gravity of the fraud on the health of buyers may be easily understood. It is to the interest of the War Office to provide the soldier with clothing suitable for the maintenance of health, while it is to the interest of the retail dealer to sell the worst possible article at the highest possible price.

The list of advantages which the soldier enjoys, and which include facilities for cleanliness, healthy amusements, libraries, etc., might be prolonged, so to speak, to infinity, but enough has probably been said to indicate the leading principles which differentiate his sanitary surroundings from those of the classes from which he is largely drawn.

Although far from conclusive, the following extract from the Army Medical Report for 1908 forms corroborative evidence of what has been stated above:

'The following table shows, for the years 1907 and 1908, the deaths and numbers invalided out of the army from the principal causes of death and invaliding among the troops quartered in the United Kingdom. The death-rate per million among the troops is given for the principal causes

of death; and for comparison with the male civil population of similar ages, the average death-rate per million from the same causes amongst males in England and Wales aged fifteen to thirty-five years for the three years 1905, 1906, and 1907 is also appended. The figures from which these rates were calculated were kindly supplied by Dr. John Tatham from the General Register Office.

Diseases.	H.M. Military Forces, 1907.			H.M. Military Forces, 1908.			England and Wales.
	Deaths.	In-valided.	Death-rate per Million.	Deaths.	In-valided.	Death-rate per Million.	Average Death-rate per Million among Males Aged 15 to 35 for 1905-6-7.
Enteric fever	13	—	110	12	2	101	148
Tubercle of lung ...	43	177	363	18	151	152	1,463
Other tubercular diseases	5	24	42	6	28	51	209
Alcoholism	3	1	25	2	1	17	35
Septic diseases (major)	5	—	42	9	8	76	52
Rheumatic fever ...	1	8	8	2	24	17	61
Diseases of the heart	30	293	253	24	220	203	314
Diseases of the circulatory system ...	18	59	152	11	37	93	55
Diseases of the respiratory system (including pneumonia)	73	48	616	50	28	422	508
Diseases of the digestive system	33	124	278	32	100	270	225
Diseases of the urinary system	21	54	177	16	50	135	124
Injuries and suicide ...	58	106	489	59	91	498	556
All other causes ...	69	791	583	58	746	489	637
Totals	372	1,685	3,138	299	1,486	2,564	4,389

Army Medical Report for 1908, p. 28.

It is often stated, by persons whose views of the service are none of the most favourable, that military life can only attract mental and physical wastrels who would be trampled underfoot in the general struggle for existence, and who find a refuge, for their weakness and incompetence, in the ranks

of the army. It is at the same time argued, with a certain amount of inconsistency, as illustrating the disadvantages of enlistment, that the army reserve man commonly finds himself among the unemployed. If he is as bad as he is represented to be when a recruit, the army can scarcely be blamed if he fails to secure satisfactory employment on discharge. Without, however, entering on the vexed topic of the quality of the recruits at the present day, it is plain that the question of the lack of employment, complained of in the case of discharged men, can only be investigated by contrasting the numbers who enlist as a result of being out of work, with the numbers who fail to find work on their return to civil life. But it is very doubtful if this line of inquiry would ever yield any satisfactory information. It is, perhaps, rather overlooked that there are a very large number of trades carried on in the army, any one of which a recruit may have the opportunity to learn, or any previous knowledge of which he may amplify, or at least maintain. Farriers, shoeing-smiths, grooms, wheelwrights, clerks, accountants, compounders of medicines, stewards, storekeepers, male nurses, telegraphists, carpenters, machinists, builders, bakers, butchers, all carry on their employments as part of their routine duties as soldiers. Supposing, which is more than likely, that a man is employed in none of these capacities, and that he takes his discharge with no better notion of any civil employment than he had on the day when he joined the colours, is he, or is he not, better qualified to obtain honest work than he was before his enlistment? Common sense answers this question in the affirmative. Some, and it is believed a large proportion, must remain unemployed; there is no concealing this fact. It is impossible to state with justice how far the blame lies with the individual, and it is, therefore, useless to make the attempt to do so. This much, however, is certain—viz., that a man who has spent certain of the most impressionable years of his life in clean and healthy surroundings; who has been called upon to constantly practise habits of order, discipline, and consequently of self-control; who has learned not to complain, but to take

his share of danger and discomfort, and to respect legitimate authority; whose muscles and frame have been developed by suitable exercise and good and sufficient food; and whose mind has had a chance to develop by travel and access to decent books, must, without any reasonable doubt, be better qualified to earn his bread in honest, if unskilled, labour than the equally unskilled civilian competitor, who by early training is fitted for little beyond the squalid pleasures of the pot-house and the slum.

'General' Booth, who in virtue of many years of experience must be no mean judge of the raw material of labour, thus speaks, in 'In Darkest England,' of the value of the discharged soldier:

'A man who has been in the Queen's army is a man who has learned to obey; he is, further, a man who has been taught in the roughest of rough schools to be handy and smart, to make the best of the roughest fare, and not to consider himself a martyr if he is sent on a forlorn hope. I often say if we could only get Christians to have one-half of the practical devotion and sense of duty that animates even the commonest Tommy Atkins, what a change would be brought about in the world!

* * * * *

'I look forward to making great use of these army reserve men. There are engineers amongst them; there are artillerymen and infantry; there are cavalrymen who know what a horse needs to keep him in good health; and men of the transport department, for whom I shall find work enough to do in the transference of the multitudinous waste of London from our town depot to the outlying farm.'*

These passages comprise the rhetorical expression of an undeniable truth.

It may possibly be objected, in connection with preceding statements, that the writer, under the influence of a prejudice in favour of the calling to which he has the honour to belong, has endeavoured to paint the hygienic advantages of military service in unduly glowing colours. To this I would reply

* 'General' Booth, 'In Darkest England.'

that every assertion, in this chapter, which refers to the internal economy of the army is simply a statement of what is common knowledge to soldiers of all ranks, and can be verified by those who wish to do so.

Any present discussion of the connection between facts stated above and the subject of universal military service would be out of place, but at the same time it is justifiable to entertain a belief that a standing army, such as now exists, is a powerful factor in the physical and mental improvement of the nation; whether such beneficial effects could or should be made to embrace more widely the community are questions which the future will decide.

In the meantime an enormous amount of work has been effected by a national spirit as expressed in the existence of the Territorial Army. It is undeniable that the periods of training are very short, but the lessons willingly learned have their influence in the details of daily life, and the Territorial soldier, in his desire to remain efficient—of which desire he has given such striking proof—will neglect no reasonable means to attain his end. It goes without saying that every organization designed to promote a patriotic spirit, coupled with moral and physical improvement, tends to the same good result. Fortunately, organizations of the kind grow and flourish amongst us, and as all these bodies are permeated with the spirit which should be found in a national army, we may take pride in the thought that we are accumulating a fund of strength which may one day prove to be an Imperial asset of no small value.

It is remarkable that recent observations carried out in connection with the French Army tend to show that, while the townsman profits physically by military service, the peasant actually deteriorates.

'Quand les uns et les autres arrivent à la caserne pour passer la visite d'incorporation, le médecin hesite souvent à recevoir le fils du bourgeois et de l'ouvrier; ils présentent, en effet, l'un et l'autre un poids inférieur à la moyenne, un développement incomplet. Le paysan, lui, rayonnant de santé, à la face rubicunde, aux muscles puissants, au poids

considérable, est accepté sans hésitation : il doit faire un bon soldat.

'Au bout de quelques mois, retournons à la caserne pour juger des transformations qui s'y sont operées.

'Celui qui était fort s'étiole petit à petit, celui qui était faible embellit de jour en jour. Celui qui avait été reconnu robustement constitué devient donc de ce fait facilement la proie de toutes les épidémies qui passent, alors que l'autre, le malingre, est presque toujours épargné ou, du moins, supporte bien mieux l'existence de la caserne.

* * * * *

'Le tableau suivant que le Colonel du 98e a bien voulu me communiquer avec l'autorisation du commandant en chef du 13e Corps, donne entièrement raison à ma théorie :

'98E RÉGIMENT D'INFANTERIE, PORTION PRINCIPALE.

'*État indiquant le nombre de militaires qui ont compté à la portion Principale en* 1906, *divisés en citadins et ruraux, leur maladies par Degré d'Instruction et leur Morbidité pour* 1000.

Division des Militaires en	Degré d'Instruction.	Nombre de Militaires Passés à la Portion Principale, 1906.	Morbidité Totale.	Subdivisions.	
				Fievreux.	Blessés.
Citadins 591	0	6	5	3	2
	1	2	0	0	0
	2	39	17	15	0
	3*	544	210	174	24
		591	232	192	26
Ruraux 920	0	42	23	22	1
	1	38	14	13	1
	2	164	78	68	8
	3*	676	292	259	29
		920	407	362	39

* '0, Ne sait ni lire ni écrire ; 1, sait lire seulement ; 2, sait lire et écrire ; 3, sait lire, écrire, et compter.—' Notre Soldat,' Lachaud, p. 50.

The sanitary condition of French barracks seems to leave a great deal to be desired, and, arguing from what we know as the general laws of health, we may expect that the agricultural labourer is more likely to suffer from overcrowding and foul air than the town-dweller, to whom a mephitic atmosphere is not uncongenial.

The lesson is not without importance to ourselves, as leading to the conclusion that if we desire universal service to be beneficial to national health, we must not shrink from maintaining our present standard of sanitation.

In connection with barracks at Courcy, Dr. Lachaud writes as follows :

'On a construit la caserne de Courcy sur les modèles datant de 1875. On n'a pas voulu tenir compte des sages conseils de l'hygiène ; on n'a pas cru bon de réaliser les innovations qui s'imposaient pour faire disparaître les différentes causes de l'ensemencement ; on a laissé subsister les chambrées, avec parquets construits économiquement et, par conséquent, mauvais ; on a toléré une aération insuffisante, un cubage d'air trop faible ; on a très certainement négligé les lavabos, les bains douches, les "water-closets" : au bout d'un an, on a récolté les fruits de la faute commise.

* * * * *

'Je ne veux pas laisser croire que j'ignore les efforts qui ont été faits pour améliorer les casernes ; mais j'estime et je dis bien haut des circulaires ne suffissent pas pour atténuer le mal. Il faut joindre l'action à la parole et à la circulaire. Cette action doit se traduire par une dépense énorme qu'il faut savoir s'imposer et qu'il faut demander au pays, pour sauvegarder autant que possible la vie des jeunes Français, qui tous, aujourd'hui, payent l'impôt du sang.'*

The concluding words of the above are pregnant with meaning as regards possibilities affecting ourselves.

To sum up—the soldier is infinitely better fed, clothed, housed, taught, cleansed, and generally cared for, morally, physically, and intellectually, than his average prototype in

* 'Notre Soldat,' Lachaud, pp. 103, 111.

civil life. What applies to the soldier applies equally to his wife and offspring, and the latter, as a matter of contrast to conditions which have been described as prevailing elsewhere, are brought into the world under circumstances which should, by counteracting those agencies in the community which directly tend to physical degeneration, produce citizens well fitted to propagate our race and maintain the integrity of our Empire.

CHAPTER XXIX

CONCLUSION

In the preceding pages evidence has been adduced in support of the theory of the self-production of disease in armies. It is well to keep carefully in mind the distinction which exists between sickness caused by circumstances which are usually the accompaniments of active service and sickness the result of endemic causes. It seems scarcely logical, or even consistent with ordinary common sense, to assume, without one particle of satisfactory evidence, that a variety of disease-producing conditions are inherent in any given locality; and such a frame of mind can only result in taking elaborate precautions against imaginary dangers, to the neglect of others of a really pressing nature. Fortunately, many measures which protect against endemic conditions are, in a general way, equally protective against diseases resulting from the circumstances of a campaign itself. In the case of water, for instance, sterilization by heat or filtration are equally efficacious against germs of all kinds, irrespective of origin. Whether enteric bacilli, or the bacillus of Flexner, or that of Shiga, are originally present in a water-supply, or whether they are washed into it from a polluted camp, makes no difference as to the excellence of measures which have been proposed regarding a supply of safe water for troops on service. The defect attendant on such proposals is that the latter tend to concentrate attention on a problematic connection which, although it would be quite unsafe to ignore, nevertheless diverts our energies from circumstances which are directly productive of the disasters

which the proposals in question are designed to eliminate. It cannot be sufficiently insisted on that the laws which produce disease in the field are exactly the same as the laws which produce disease anywhere else. A hypothetical illustration may make this matter clear.

Suppose that in a civilized community dust-carts and water-closets were abandoned; that the wants of Nature were complied with by means of holes dug within a few yards of dwelling-houses; that we carried into living apartments, on boots and on clothing, traces of the relics attendant on our primitive arrangements; that no adequate form of covering for excretal filth was in use; that flies transferred themselves from excrement to food, or *vice versâ*, with equal facility; that paper used for unnamable purposes was commonly found on articles of furniture; that we buried our kitchen refuse at our very doors, or, having made an abortive attempt to burn it, that we allowed it to blow into our houses in the form of dust—suppose in the face of this state of affairs that the only possible explanation we could advance for an outbreak of enteric fever was the presence of the typhoid bacillus in the water-supply, we should surely be guilty of almost as complete a *non sequitur* as that of a well-known character, in English literature, who accounted for the name of Stony Stratford on the ground of his never having been anywhere near the locality in question.

In camps the dwellings of men are surrounded by uncovered, or partially covered, collections of refuse; filth is disseminated on boots and persons; paper from latrines is blown here and there; and food is polluted by dust and flies. If such conditions surrounded us in the time of peace, sanitary authorities would not be at loss to account for the various epidemics which would in all probability arise. Why, then, in war should we go out of our way to find a cause for sickness, which during peace would have an immediate explanation in grossly-insanitary surroundings?

It seems, on the face of it, about as reasonable to expect to find the bacillus of enteric and that of dysentery in the streams and soil of the sparsely populated regions of Natal as

it would be to expect a similar discovery in the streams and soil of Dartmoor, or in the uttermost wilds of Connemara. This is no argument against the purification of water in the field ; the possible existence of dangerous animalculæ is quite sufficient to necessitate this step, besides which the chance of pollution from the presence of troops is always present.

Within certain limits an army holds its fate, in the direction of health, in its own keeping; and this should be the guiding principle in many of our most important measures. It is a regrettable fact that the elastic nature of the term 'sanitary' prevents the work of the medical department from having any definite boundaries, so that questions of organization with which considerations of health are connected may sometimes be decided without reference to the arm of the service which specially exists for the purpose of offering advice on subjects of the kind. At present, medical officers are often entirely in the dark concerning impending operations, and are thus debarred from expressing opinions concerning such questions as quantity of rations to be carried, nature of shelter—whether tents or otherwise—clothing, etc. As far as military exigencies allow, the influence of sanitation should extend into every detail of the soldier's life, and, judging from published statements, the recent success of the army of Japan was in some measure due to the practical application of this principle.

To carry the above principle to its logical conclusion would mean a considerable widening of duties and responsibilities. Contracts for food-supplies, materials for clothing, and many other matters bearing on physical efficiency, would come officially—as they already do legitimately—within the jurisdiction of the medical officer ; the principle would, in short, give full play to his recognized function of eliminating all those forces, in the shape of sanitary defects, of which the completed evolution of disease is the resultant (see p. 196).

To ask for an opinion does not imply any obligation to act on it, and it could not complicate official machinery if

medical officers were given the opportunity of stating their views on the purely sanitary aspects of proposed military schemes. There is no occasion to attribute an omission in asking the advice of a professional expert to a malevolent wish to inflict a wanton insult. With scarcely an exception, I have found recommendations courteously received and faithfully carried out, and commanding officers are not unappreciative of efforts undertaken with the object of maintaining the best possible standard of physical efficiency in their units. To bring home to the mind, however, the actual value of sanitary advice, an alteration in regulations seems to be desirable. It is laid down that medical officers are to offer advice, but it is nowhere stated that the purely military authorities are to ask it; and the obligation to ask as well as to offer might well, in this connection, receive official recognition.

To obtain good results from sanitary advice, the adviser should be supplied, as far as possible, with schemes of proposed operations, for in the absence of this information it would be impossible to proffer recommendations adapted in all cases to the conditions with which he might be called upon to deal. It is quite likely that the 'foolish' suggestions which, according to a well-known statement, emanated from a sanitary officer were due to the latter being kept in ignorance of the circumstances which rendered him liable to the scorn which his proposals provoked.

A divisional sanitary officer is now included in field establishments; the wisdom of this step is unquestionable, provided that the nature of his work receives liberal interpretation. No one is likely to dispute the fact that the duty of a sanitary officer is rather to prevent disease than to investigate its causation when it has already come into being. To prevent disease necessitates a knowledge of the conditions which are likely to produce it, and in the field this knowledge would certainly comprise full information of the task which a force might be called upon to perform, together with every detail of physical environment likely to influence the final result.

It may be that in the near future the field of usefulness of the medical officer will be enlarged, and that his advice will be considered essential, both in peace and war, in connection with comprehensive schemes, the success of which is closely associated with questions of sanitation and, consequently, with the physical condition of troops. Hitherto the medical department has been looked on as the author of increased labour resulting from suggestions as to what it deemed necessary, while the converse of the above has been, comparatively speaking, disregarded, although it is certain that skilled opinion is equally in a position to state what is *not* as well as what *is* actually essential. Can anyone doubt the value of such counsel in the case of a force engaged in a hazardous enterprise, when national interests hang in the balance, when speed of movement is essential for success, and delay means disaster and defeat ?

Day by day the influence of preventive medicine is making itself better felt, while the recently extended scope of the medical department of the army is an expression of the common-sense principle that all available knowledge should be developed and utilized for the service of the State.

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